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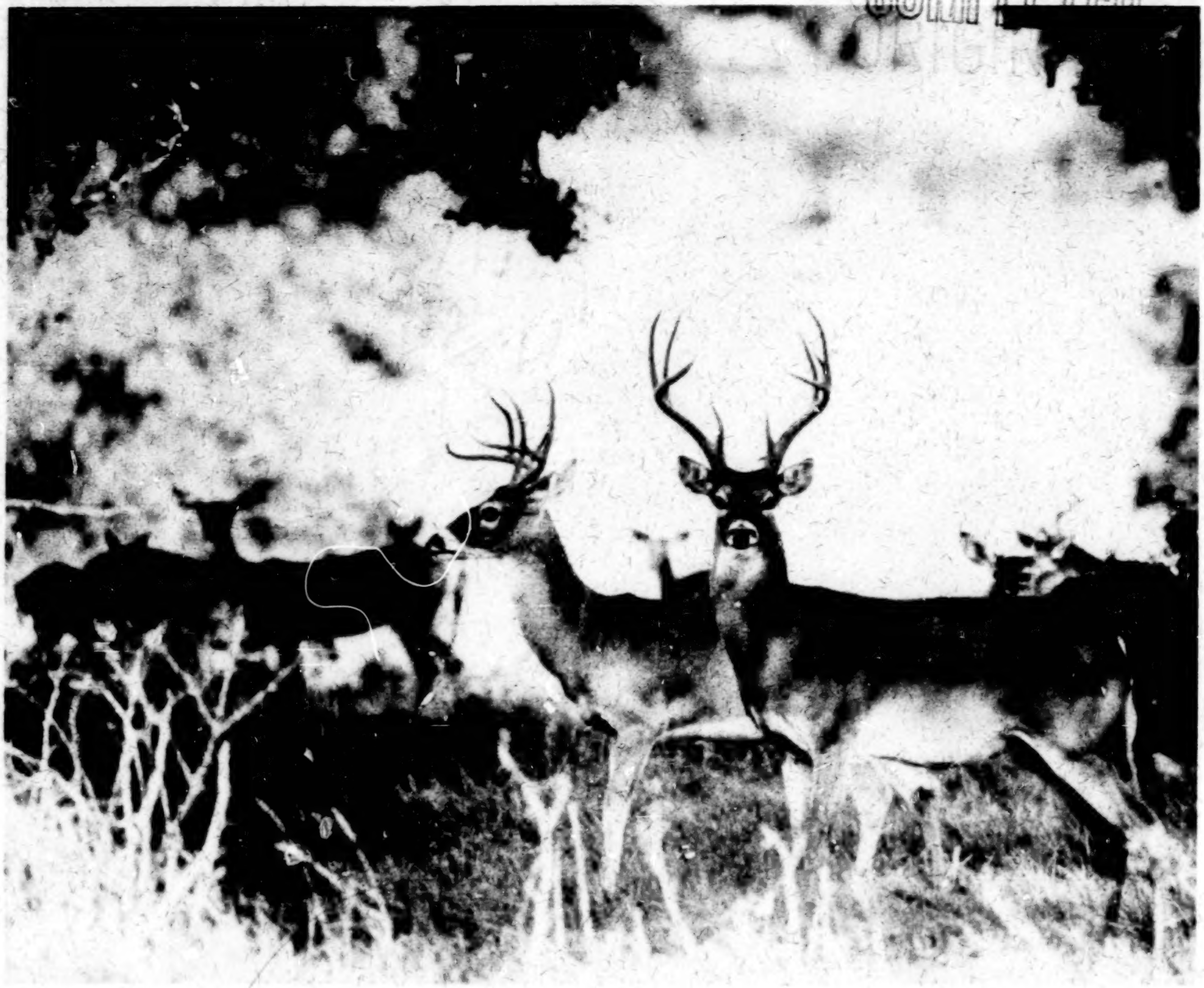

REVEGETATING SURFACE MINED LANDS FOR WILDLIFE IN TEXAS AND OKLAHOMA

Fish and Wildlife Service

U.S. Department of the Interior

(134)

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues that impact fish and wildlife resources and their supporting ecosystems.

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On the cover: A herd of white-tailed deer in the Post Oak Savannah of Texas. Photo courtesy of Texas Parks and Wildlife Department.

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

EASTERN ENERGY AND LAND USE TEAM
Route 3, Box 44
Kearneysville, West Virginia 25430

September 21, 1981

Dear Colleague:

The Eastern Energy and Land Use Team (EELUT) is pleased to provide you with this product entitled "Revegetating Surface Mined Lands for Wildlife in Texas and Oklahoma" FWS/OBS-81/25. This product has been prepared by Kenneth L. Dickson and Dwain Vance of the Institute of Applied Sciences and Department of Biological Sciences, North Texas State University, Denton, Texas.

This manual includes procedures and discussions encouraging reclamation of surface mined lands for wildlife in Texas and Oklahoma. Methods are described that facilitate the creation of habitat diversity that will attract and support wildlife. The specific purpose of this manual is to provide guidance on the conception, development, and implementation of wildlife habitat restoration on reclaimed lands in Texas and Oklahoma.

We are interested in your evaluation of this document and suggestions for future EELUT products.

Sincerely,

Edgar A. Pash

Edgar A. Pash
Team Leader, EELUT

FWS/OBS-81/25
August 1981

REVEGETATING SURFACE MINED LANDS FOR WILDLIFE IN TEXAS AND OKLAHOMA

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PREFACE

The Surface Mining Control and Reclamation Act of 1977 (P.L. 95-87) mandates that all current and future mining be performed according to sound environmental standards using the Best Technology Currently Available (BTCA) and that all mined lands be restored to their original or better use. Numerous postmining land uses are permitted under the Act, including reclamation for fish and wildlife.

This guide includes procedures and discussions encouraging the preservation and reclamation of surface mined lands in Texas and Oklahoma for wildlife. Even on those sites where reclamation will be oriented primarily toward agricultural purposes (e.g., tame pasture, commercial forest, etc.), there are numerous ways to include wildlife in the reclamation plan. Methods and procedures are recommended in this guide that will make possible the creation of a diversity in habitats that will attract and support wildlife. The specific purpose of this publication is to provide guidance on the conception, development, and implementation of revegetation plans that help to retain, create, and maintain wildlife habitat on reclaimed lands in Texas and Oklahoma.

Questions concerning this guide should be directed to:

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SUMMARY

Lignite and bituminous coal seams occur in three major vegetational areas in Texas: Pineywoods, Post Oak Savannah, and South Texas Plains. In Oklahoma, bituminous deposits occur primarily within the oak-hickory-pine forests and tall grass prairies which are comparable to the Post Oak Savannah. Each of these areas is discussed in terms of native vegetation, soils, and climate.

The development of a revegetation plan for surface mined lands to benefit wildlife is discussed in terms of the basic requirements of wildlife, the establishment of a management goal, and the designing of a revegetation plan. A practical revegetation plan is included as an example, showing the sequential steps involved in the design and implementation of a plan that assures good diversity in habitats. Estimated incremental costs associated with the establishment of wildlife plantings are also included.

One section of the guide is devoted to methods of establishing vegetation for wildlife use. General discussions are included on land preparation and the selection of plant species useful for wildlife. More specific considerations related to the establishment of herbaceous species follow these general guidelines. Suggested seeding mixtures and techniques for each of the three vegetation regions are given. The section concludes with a treatment pertaining to the establishment of woody species. Addresses of State and Federal agencies that assist in revegetation planning and commercial sources that provide plant stocks have been provided in the Appendixes.

Throughout this guide, emphasis is given to methods of reclaiming lands in ways that result in the greatest possible variety of vegetation and topography, which subsequently result in greater wildlife diversity.

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A number of universities aided by making available unpublished theses and dissertations, as well as published materials pertinent to the revegetation of surface mined areas. These include Texas A&M University, The University of Texas at Austin, Stephen F. Austin University, Oklahoma State University, and The University of Oklahoma.

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1. INTRODUCTION

This guide arises out of a recognition that the future will see a notably accelerated increase in coal surface mining activities in the States of Texas and Oklahoma and that regional-specific guidelines for reclamation of these lands for fish and wildlife resources are not readily available.

Texas alone has over one million surface acres of land potentially subject to lignite development (Kaiser 1974; Holm 1975). Much of this lignite (approximately 12.2 billion short tons) is estimated to be within 200 ft of the surface (Kaiser 1974, 1978). Oklahoma, although not rich in lignite reserves, has substantial bituminous coal deposits available to surface mining (Friedman 1977; Arndt and Mankin 1978).

Valuable fish and wildlife resources will be lost in Texas and Oklahoma due to surface mining activities unless best management practices and habitat restoration techniques[1] can be included as part of the reclamation program for the mined lands. Also, the development of a public awareness that both economic and aesthetic benefits can arise if reclamation includes restoration of fish and wildlife habitats must be generated (Cloud 1978).

There are numerous reasons for reclaiming mined lands for wildlife. In Texas and Oklahoma, wildlife is a valuable natural resource contributing many thousands of dollars to the States each year. The inclusion of fish and wildlife in a reclamation plan may not increase the costs of reclamation substantially and may in the long run be the best land use alternative for many sites. Fish and wildlife lands may also be more likely to endure with a minimum potential for future problems. Regardless of the ultimate objective of reclamation, fish and wildlife can always be included in the reclamation plan as a secondary land use.

The specific kinds and abundance of wildlife to consider in any relamation plan will depend on the ecological requirements of target species, the preferences of the landowners or land managers, and on the physiochemical and biological relationships of the site.

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[1] Mention of trade names, commerical products, or seed sources does not constitute endorsement or recommendation for use by the Federal Government.

To support wildlife, satisfactory habitats must be created. Habitats include the following essential things: food, water, cover, and living space (range). Generally, an area with a variety of habitats can support a variety of wildlife. Diversity is the key to reclamation for wildlife and any reclamation program including wildlife should stress diversity of habitat, topography, and vegetation (Parris 1975).

While techniques for restoring fish and wildlife habitats following surface mining in the Eastern and Western United States have been developed (Riley 1954; Vories 1976; Utah State University 1978; Rafaill and Vogel 1978; Samuel _et al_. 1978; U.S. Forest Service 1979a; Vogel 1981; and others), the applicability of similar techniques to the Texas-Oklahoma area is presently unknown. Thus, this guide grows out of an awareness that a need exists for the development of guidance materials related to fish and wildlife habitat restoration in Texas and Oklahoma surface mining areas.

In the sections that follow, the major vegetation regions in Texas and Oklahoma where lignite or bituminous coal surface mining will occur are discussed; the basic habitat requirements of wildlife are identified; and guidance is provided for developing a revegetation plan for wildlife. Information on what kinds of vegetation are useful to wildlife and where to obtain seeds or planting stock is also included. Finally, suggestions on how to establish vegetation for wildlife habitat are made, and an example is given on how to estimate the incremental costs of implementing a wildlife revegetation plan.

2. VEGETATION REGIONS/COAL DEPOSIT ASSOCIATIONS

The major near-surface deposits of lignite in Texas occur in two bands encompassing three principal formations: the Wilcox, Yegua, and Jackson formations. These formations extend from the northeast corner of Texas to the Rio Grande River in southwest Texas (Kaiser 1974; Radian Corp. 1978). Bituminous coal deposits are located in northcentral Texas and along the Rio Grande (Figure 1).

In Oklahoma, major bituminous coal deposits occur in the eastern part of the state, extending from Craig County southward to Coal and Atoka Counties (Figure 1). The easternmost deposits occur in LeFlore County (Friedman 1977).

The lignite beds lie within three major vegetation regions in Texas: Pineywoods, Post Oak Savannah, and South Texas Plains. The bituminous coal deposits in northcentral Texas generally occur in the Cross Timbers and Prairies vegetation regions (Gould 1975). The Cross Timbers and Prairies have previously been considered an extension of the Post Oak Savannah to the west (Weaver and Clements 1938). Therefore, discussions on these vegetation regions have been combined under the Post Oak Savannah.

In Oklahoma, bituminous coal occurs within the oak-hickory, oak-pine forests and tallgrass prairie vegetation regions (Duck and Fletcher 1943). Generally speaking, these Oklahoma vegetation regions have flora and physiochemical characteristics comparable to the Post Oak Savannah Region of Texas. Therefore, these vegetation regions have also been combined as Post Oak Savannah. Figure 2 illustrates the generalized vegetation regions utilized for the presentation of materials within this guide.

The Pineywoods vegetation region generally corresponds to the southeastern mixed forest, Ecoregion 2320 as defined by Bailey (1978), while the Post Oak Savannah corresponds to Bailey's Ecoregion 2510, the prairie parkland province. The South Texas Plains vegetation region is comparable to Bailey's Ecoregion 2520, prairie brushland.

The range of near-surface coal formations in Texas and Oklahoma covers a very large area, encompassing a variety of climatic, edaphic, and biotic regions. Consequently, successful reclamation programs will have to be planned to meet the needs of each specific area.

In this section, each of the three vegetational regions are described in terms of their climatic, edaphic, and biotic factors. This information is needed so that better judgements can be made in determining the best

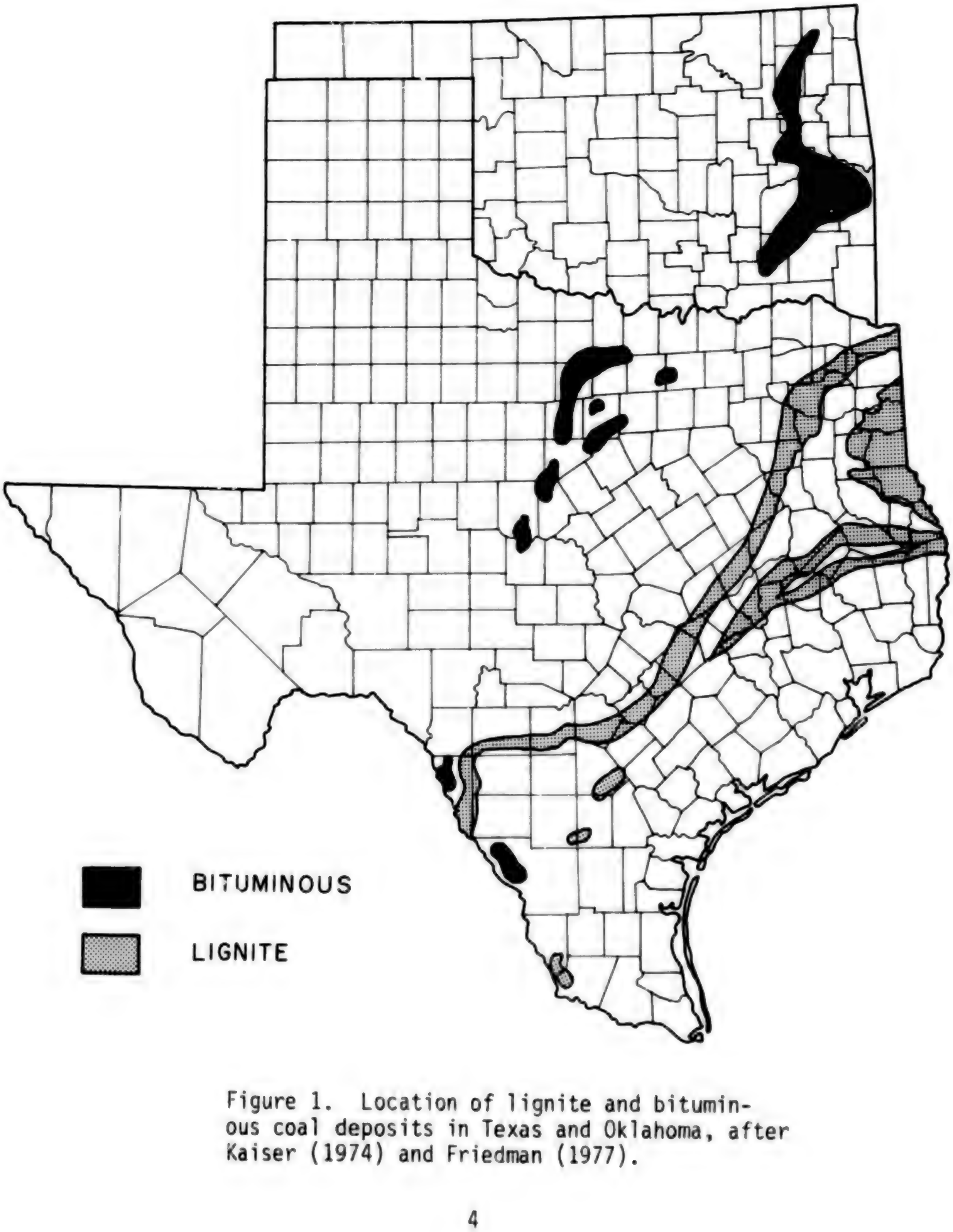

Figure 1. Location of lignite and bituminous coal deposits in Texas and Oklahoma, after Kaiser (1974) and Friedman (1977).

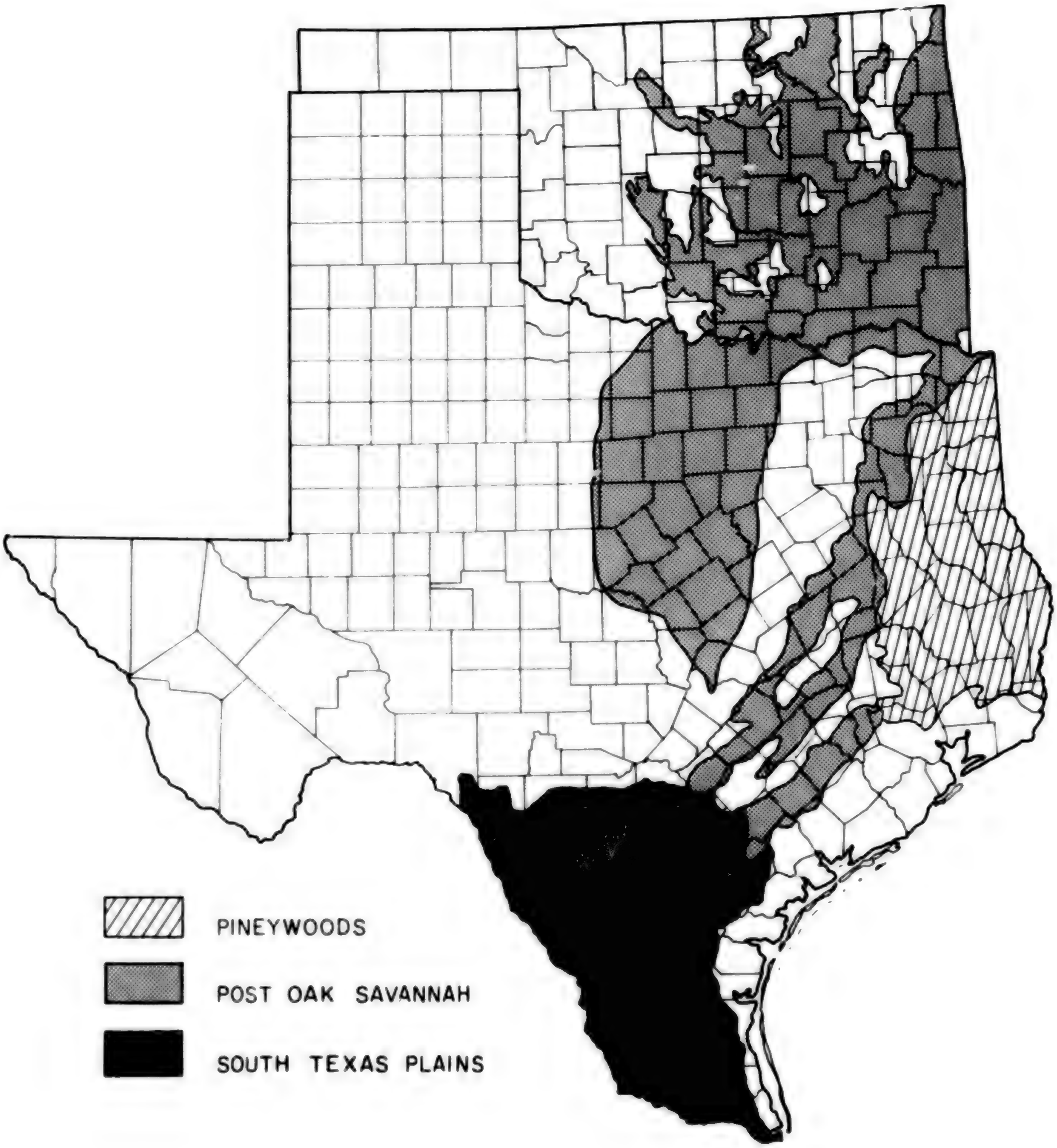

Figure 2. Location of vegetation regions associated with bituminous coal and lignite deposits in Texas and Oklahoma.

ways to revegetate spoils for wildlife use. The intent is not to provide details required for on-site revegetation programs; rather, the information in this section can be used to provide planners with a generalized view of important factors to be considered in the formulation of a concept of reclamation that includes revegetation for wildlife. The development of an on-site revegetation plan for wildlife and its implementation is fully discussed in a later section of this guide.

PINEYWOODS

The Pineywoods vegetation region consists of gently rolling to hilly forested land in East Texas. It is the southwestern extension of the pine-hardwood forest of the Eastern United States (Holm 1975). This association also extends into far eastern Oklahoma, but coal deposits in that state lie farther west.

Annual rainfall in the Pineywoods ranges from about 50 inches per year in the southwestern sector to about 35 inches per year in the northern sector, and it is evenly distributed on a monthly basis. Consequently, this is the most mesophytic area of Texas. The entire area is characterized as having mild winters and high summer temperatures. There is no persistent wind and the humidity is high. The area has a frost-free season of 235 to 265 days (TX Agr. Exp. Station, 1931).

Soils in the Pineywoods Region are mostly acidic and light-colored with low organic content (TX Agr. Ext. Station, 1931). The two dominant soil orders are the Alfisols and Ultisols. Alfisols are described as having a light-colored surface layer over developed, more clayey subsoil and as having a moderate-to-high base saturation. Ultisols have light-colored sandy to loamy surface layers over developed, more clayey subsoil; they are low in bases and, therefore, acidic throughout. Other soil orders (Mollisols, Inceptisols and Entisols) are present in smaller acreages throughout the whole area.

The Pineywoods Region of Texas often is divided into two major vegetation areas: the pine forest and the pine-oak forest. The pine forest has its eastern boundary along the Sabine River, with its northern limit in Shelby County, extending westward to Montgomery, Walker, and Houston Counties and southward to Orange County (Holm 1975). Ecologically, the pine forest area is primarily a mixed forest; however, commercial forest management has increased the predominance of pines.

The pine-oak forest forms an ecotone between the eastern pine forest and the Post Oak Region on the west. The pine-oak ecotone extends from the Red River to the coastal prairie, encircling the pine forest on the north and west. Most of the lignite deposits within the Pineywoods Region occur in this pine-oak area.

Forests predominate throughout the Pineywoods Region. However, the Region is interspersed with native vegetation, pasture, and farmlands (Gould 1975). Open areas, especially in the pine-oak area occur, but not in large numbers.

In the Pineywoods Region, loblolly pine (*Pinus taeda*) and shortleaf pine (*Pinus echinata*) are dominant with a variety of hardwood species present throughout the overstory. Especially in the pine-oak area, such species as southern red oak (*Quercus falcata*), post oak (*Quercus stellata*), and blackjack oak (*Quercus marilandica*) tend to form a second canopy. Species of less common occurrence include the hickories (*Carya* spp.), water oak (*Quercus nigra*), blackgum (*Nyssa sylvatica*), hackberry (*Celtis* spp.), sassafras (*Sassafras albidum*), and elms (*Ulmus* spp.). The understory is comprised of a number of shrubs, including the American beautyberry (*Callicarpa americana*), dogwoods (*Cornus* spp.), hawthorns (*Crataegus* spp.), hollies (*Ilex* spp.), Hercules' club (*Xanthoxylum herculis*), bayberry (*Myrica cerifera*), sumacs (*Rhus* spp.), coral berry (*Symphoricarpos orbiculatus*), and several additional species.

Forage plants in the Pineywoods are predominantly species of the grasses such as bluestem (*Andropogon* spp.), panicums (*Panicum* spp.), lovegrasses (*Eragrostis* spp.), Indiangrass (*Sorghastrum nutans*), Dallisgrass (*Paspalum dilatatum*), and spanglegrasses (*Uniola* spp.). Legumes of importance include partridge pea (*Cassia fasciculata*), wild pea (*Lathyrus hirsutus*), lespedezas (*Lespedeza* spp.), sesbania (*Sesbania exaltata*), and clovers (*Trifolium* spp.).

Throughout the Pineywoods, especially in drier areas, several species of vines are common. These include peppervine (*Ampelopsis arborea*), trumpet creeper (*Bignonia radicans*), Carolina jessamine (*Gelsemium sempervirens*), Virginia creeper (*Parthenocissus quinquefolia*), greenbriar (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), poison oak (*Toxicodendron quercifolium*), and various species of grapes (*Vitus* spp.).

The introduction of grasses and legumes for improved pastures has greatly changed the pattern of vegetation in much of the Pineywoods Region. The most important introduced grasses are common and coastal bermuda grass (*Cynodon dactylon*), Dallisgrass, Vaseygrass (*Paspalum urvillei*), carpetgrass (*Axonopus affines*), Kleingrass (*Panicum coloratum*), and King Ranch bluestem (*Bothriochloa ischaemum*). The major legumes introduced are crimson clover (*Trifolium incarnatum*), and Yuchi arrowleaf clover (*Trifolium vesiculosum*).

Special mention should be made of the bottomlands that occur throughout the Pineywoods Region. These areas are usually adjacent to or near the streams and rivers and are typically wet, swampy areas having unique flora (Holm 1975). Hardwood species are dominant in these bottomlands, the most abundant including Shumard oak (*Quercus shumardii*), overcup oak (*Quercus lyrata*), willow oak (*Quercus phellos*), hickory, sweetgum (*Liquidambar styraciflua*), blackgum, water tupelo (*Nyssa aquatica*), and sycamore (*Platanus occidentalis*). In local areas, ash (*Fraxinus* spp.) and American beech (*Fagus grandifolia*) may be rather common with occasional cottonwoods

(*Populus deltoides*) scattered throughout. Bald cypress (*Taxodium distichum*) is an important species throughout the Sabine River drainage area. Other species of lesser importance include red maple (*Acer rubrum*), hophornbeam (*Ostrya virginiana*), American holly (*Ilex opaca*), and magnolia (*Magnolia grandiflora*). Numerous shrubs and herbaceous species that occur commonly, especially in the moister areas, are the hollies (*Ilex* spp.), elderberry (*Sambucus canadensis*), coral berry, buttonbush (*Cephalanthus occidentalis*), arrowwood (*Viburnum dentatum*), willow baccharis (*Baccharis* sp.), dogwoods, farkleberry (*Vaccinium arboreum*), poison ivy, greenbriar, grape, and several others.

The Pineywoods Region contains numerous complex associations of forbs and shrubs, all interacting with the dominant woody species (Correll and Johnston 1970). The situation has been complicated by the introduction of grasses and legumes for improved pastures and pines for commercial forests.

POST OAK SAVANNAH

This gently rolling to hilly region has the Pineywoods as its eastern border and the Blackland Prairie as its western limits. (Gould 1975). The Blackland Prairies extend into the Post Oak Savannah as islands in the southern part of the region (Figure 2). Also, numerous small isolated prairies occur throughout the region. Earlier reports (Engeling 1951; Truett 1972; Mahler 1973) described the area as a grassland with scattered large trees, predominantly post oak (*Quercus stellata*).

Weaver and Clements, in 1938, included the Cross Timbers Region as part of the Post Oak Savannah. The Cross Timbers being the southern extension of the oak-hickory forest which is a continuous hardwood formation extending from southeastern Minnesota through northeastern Texas. Although different opinions exist, most ecologists agree that the grasses are the climax dominants in this region and that the predominant oaks are relicts of a moister climate (Allen 1974).

Rainfall averages 35 to 45 inches per year in the Post Oak Savannah Region and tends to be seasonal with May and June being the high rainfall months. Summers are often characterized by drought. Temperatures are mild during the winter and hot during the summer resulting in moderately high humidity during most of the year.

The soils of the Post Oak Savannah Region of Texas are generally classified as claypan soils that are light-colored and medium to slightly acid (TX Agr. Exp. Station 1931). The major soil order is Alfisols, and the soils have loamy to sandy surfaces underlain with red, gray, and/or yellow cracking clayey subsoils. In eastern Oklahoma, the soils are light-colored, acid, sandy to loamy developed on sandstone and shales. The westernmost soils of the Post Oak Savannah in Oklahoma are dark with clayey subsoils. These soils developed on shales, sandstones, and limestones (OK Agr. Exp. Station 1959). These rather shallow soils are the major determining factor for the vegetation.

Biotically, the Post Oak Savannah Region includes plant associations distinctive of uplands, ephemeral streams, and bottomlands. Virtually all of the Region has been disturbed to some extent. Cattle have grazed most of the wooded areas and most of the land has been cleared for pastures and/or agronomic crops.

Upland Areas

The upland areas of the Region have been greatly disturbed, principally through overgrazing and the exclusion of fires. Woody species increased in percentage relative to native herbaceous species, including grasses, as grazing pressure increased from 15 to as few as 5.1 acres per animal (McCaleb 1954). It is not at all uncommon to see evidence that the woody species have subsequently decreased due to this very high ratio of animals to acreage; the cattle are forced to utilize the woody vegetation as forage. In the disturbed areas, winged elm (*Ulmus alata*), greenbriar (*Smilax* spp.), hollies (*Ilex* spp.), and plum (*Prunus americana*) comprise the major invaders. Willow baccharis (*Baccharis* sp.) is a serious invader in the more open areas where the soil remains moist. Other common invaders include hackberry (*Celtis* spp.) and cedar elm (*Ulmus crassifolia*) along with mesquite (*Prosopsis glandulosa*) and prickly pears (*Opuntia* spp.), especially on the more clayey soils.

Holm (1975) has correctly pointed out that the density and species diversity of the undergrowth varies in accordance with grazing pressure, soil characteristics, topography, and available water. Small trees and shrubs such as yaupon (*Ilex vomitoria*), winged elm, American beautyberry (*Callicarpa americana*), eastern red cedar (*Juniperus virginiana*), hawthorns (*Crataegus* spp.), dogwoods (*Cornus* spp.), coral berry (*Symphoricarpos orbiculatus*), and a few others are common in the more moist, densely vegetated areas.

Woody vines constitute a major component of vegetation in the wooded areas. Greenbriar and grape (*Vitis* spp.) are especially prevalent and often form almost impenetrable entanglements. Other vines include Virginia creeper (*Parthenocissus quinquefolia*), peppervine (*Ampelopsis arborea*), and dewberries (*Rubus* spp.). Poison ivy (*Toxicodendron radicans*) is abundant throughout the upland area.

In the far southwestern part of the Post Oak Savannah, a population of loblolly pines (*Pinus taeda*) occurs on gravelly terraces formed by the Colorado River. This area, called the "Lost Pines," resembles the upland vegetation of the Pineywoods Region. However, the vegetation is not the same; the understory vegetation is much more similar to that of the Post Oak Savannah, and post oak and blackjack oak (*Quercus marilandica*) are more prevalent in the "Lost Pines" than in the Pineywoods. These pines apparently are remnants of a once extensive East Texas pine forest from a cooler, moister climate.

Ephemeral Streams

Ephemeral streams are found throughout the Post Oak Savannah Region. Most of these streams are dry most of the year, containing water only for a short period of time following local rains. The vegetation along these streams is quite similar to that of the upland areas. Certain species such as dogwoods, grape, cedar elm, and Virginia creeper increase in density as soil moisture increases.

There are several streams in this area that contain water most of the year. These intermittent streams have floodplain areas with sandy to loamy (usually clay-loam) soils that tend to be moister than those soils associated with the more ephemeral streams. Consequently, the vegetation along these streams is similar to that of the bottomlands. If oaks are present at all, they tend to be water oak (*Quercus nigra*) or, only occasionally, southern red oak (*Quercus falcata*). The dominant tree species are pecan (*Carya illinoensis*), hackberry and sugarberry (*Celtis* spp.), cedar elm, American elm (*Ulmus americana*), hickories (*Carya* spp.), mulberries (*Morus* spp.), ash (*Fraxinus* spp.), and dogwoods. Near the water, one finds black willow (*Salix nigra*), box elder (*Acer negundo*), hickory, and some cottonwoods (*Populus deltoides*).

The ephemeral stream areas often tend to be more disturbed than the upland areas. This is due to the fact that most available water for cattle and wildlife occurs in these streams.

Bottomlands

The floodplains of rivers and perennial streams comprise the bottomlands. The soils of these areas are less acidic than the upland soils and they are flooded periodically throughout the year; moisture is, therefore, usually available.

The vegetation of the bottomland areas is often similar to that of the intermittent stream areas, but is generally more diverse due to the greater availability of water. Willows and cottonwoods are more numerous along the stream and river beds than they are in other areas. Due to periodic flooding, understory shrubs tend to be generally less dense; native grasses and a few vines may be quite dense.

SOUTH TEXAS PLAINS REGION

The southern extension of the lignite beds lie within the South Texas Plains vegetational region. This Region (Figure 2) consists of level to rolling land that is dissected by numerous streams emptying into the Gulf of Mexico. Elevations range from sea level along the coastal areas to some 1,000 ft in the north and western areas.

The South Texas Plains Region is sometimes referred to as the Rio Grande Plains Region. This Region has an annual rainfall of 16 to 35 inches, increasing from west to east. The mid-summer months are often dry and very high evapo-transpiration rates occur. Temperatures exceeding 100°F/39°C are common during the summer; winter temperatures are generally mild.

Soils of the South Texas Plains are composed predominantly of the following orders: Alfisols, Vertisols, Mollisols, Entisols, Aridisols, and Inceptisols (TX Agr. Exp. Station 1931). The soil associations within these orders vary over a wide range from deep, loamy, well-drained soils to those that are shallow, clayey, and poorly-drained. Consequently, numerous kinds of plant associations are supported within the Region.

Most of the acreage within the South Texas Plains Region is rangeland, with a substantial part devoted to primary agricultural land. According to Gould (1975), this entire region originally was a grassland or a savannah. Over the years, increasing pressures on the land, especially by grazing, have resulted in the vegetation of today which includes many species of woody plants such as mesquite (*Prosopis* spp.), post oak (*Quercus stellata*), acacias (*Acacia* spp.), and numerous cacti. A few junipers (*Juniperus virginiana*) occur, but these amount to well less than 1 percent of the woody vegetation. Cottonwoods (*Populus deltoides*) and willows (*Salix* spp.) are found in moist areas along streams.

Shrubs occur in association with the wooded areas. The major species include yaupon (*Ilex vomitoria*), French mulberry or beautybush (*Callicarpa americana*), and black haw (*Viburnum rufidulum*) in the sandy soils and in the more open woods. In moister areas, coral berry (*Symphoricarpos orbiculatus*) is commonly found.

Due to differences in soil types and formations, as well as differences in climatic conditions over the Region, it is not surprising to find many distinct differences in climax plant communities on the various sites. The sandy loam soils support grasses such as seacoast bluestem (*Schizachyrium scoparium*), bristlegrasses (*Setaria* spp.), sandbur (*Cenchrus myosuroides*), tanglehead (*Heteropogon contortus*), and various species of the genera *Paspalum*, *Trichloris*, and *Chloris*. Dominant species on the clayey soils are longspike silver bluestem (*Bothriochloa saccharoides* var. *longipaniculata*). California cottontop (*Digitaria californica*), buffalograss (*Buchloe dactyloides*), and several species of *Setaria*, *Paspalum*, and *Bouteloua*. In the savannah areas, the major grasses occurring with the oaks are seacoast blue-stem, Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and several species of *Paspalum* (Gould 1975). Along the lower, more saline areas, one finds cordgrass (*Spartina spartinae*), seashore saltgrass (*Distichlis spicata*), switchgrass, and alkali sacaton (*Sporobolus airoides*).

3. DEVELOPING A REVEGETATION PLAN TO ENHANCE WILDLIFE

Surface mined land can be reclaimed for a variety of uses, all of which must take into consideration the effects of reclamation on fish and wildlife, according to the Surface Mining Control and Reclamation Act. The Act and promulgated regulations, in most cases, leave the postmining land use option open to the mine operator with the concurrence of the surface landowner. Guidance, however, has been written into the Act and regulations to ensure that a landowner's fish and wildlife resources are not forgotten in the postmining land use plan. Specific approval of the regulatory authority is required for postmining land use changes.

First, it is important to contact local fish and wildlife management agencies early in the planning process. These agencies can assist in the evaluation and planning to determine the type of reclamation most feasible for the specific wildlife needs of the area to be reclaimed. A list of State and Federal agencies in Texas and Oklahoma offering assistance can be found in Appendix A.

Long-range reclamation for wildlife is best carried out by utilizing a combination of management practices designed to promote several wildlife species (Parris 1975; Frentress and Spain 1980). The landowner can then reap the multiple benefits of having several game and nongame species on his land. A number of game species can obviously offer the landowner a greater variety of wildlife to hunt. Nongame species, on the other hand, may provide benefits such as insect and pest control which are often unnoticed by the landowner. This is in addition to the aesthetic enjoyment often derived from listening to and observing the many species of nongame wildlife.

A major consideration in the reclamation process for wildlife is that the best reclamation is often simply preservation. That is, areas critical to the needs of wildlife may be spared during the mining operation. In many cases this will make the process of reclamation easier, simpler, and less expensive. For example, the preservation of a 100-300 ft buffer zone around streams will provide habitat for many game and nongame species, while providing a seed source for natural invasion of disturbed areas.

BASIC REQUIREMENTS OF WILDLIFE

Fish and wildlife species depend on a diversity of vegetation, other wildlife, and non-living factors. Maintenance of these elements, which make up the habitat of the animal, is paramount if successful establishment of wildlife communities is to occur as a result of reclamation.

Habitat

Habitat is the term used to define the food, cover, space, and water needs of an animal. If any aspect of an animal's habitat is missing, the animal will either perish or migrate from the area. Thus, it is essential in preparing a plan which has wildlife as a primary or secondary land use to provide for all aspects of habitat. Not all animals require the same habitats. For example, the habitat requirements of the bobwhite quail differ from those of the white-tailed deer. An understanding of the requirements for food, cover, space, and water of desired species is essential in revegetating surface mined lands for wildlife.

Food

Establishing plants which will provide a full year's supply of food for wildlife on surface mined lands requires careful planning. Most animals will use a variety of foods in order to have a stable diet year-round. If a revegetated area provides ample food for three seasons, but is lacking food during the winter, it will not support viable populations of wildlife which have small home ranges. Not only do wildlife have varied diets throughout the year, but throughout their life cycles as well. Young bobwhite quail eat primarily insects; older quail eat seeds of grasses and herbs, as well as green vegetation.

The carrying capacity of reclaimed surface mined lands is to a large degree determined by the availability of food. Selection of plants which can be used as browse and/or those which form fruits, seeds, or nuts is essential. Table 1 lists a variety of high value food plants that are preferred by some selected species of birds and mammals. Some of the plants listed, especially the weeds, are not commonly

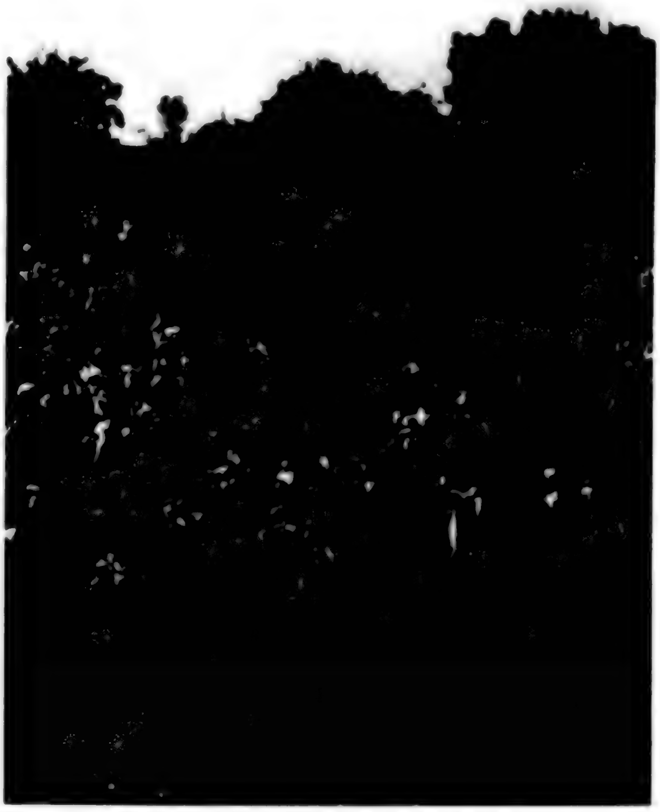

Figure 3. Doveweed (croton), a favorite food for doves.

Table 1. Examples of high value wildlife food plants by species preference.[a]

	White-tailed deer	Cotton-tail rabbit	Non-game birds	Wild turkey	Bob-white quail	Water-fowl	Mourning dove
Coniferous Trees							
Pines	X		X	X	X		
Eastern red cedar	X		X	X			
Hardwood Trees							
Crabapple	X	X					
Maples	X		X				
Black walnut	X						
Blackgum	X		X				
Persimmon	X						
Black willow	X						
Cherry	X	X	X	X			
Hackberries	X		X	X			
Elms	X		X	X			
American beech			X	X			
Sycamore	X		X				
River birch			X				
Oaks	X		X	X	X	X	
Hickories	X		X	X		X	
Dogwoods	X	X	X	X		X	

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Table 1. (Continued)

	White-tailed deer	Cotton-tail rabbit	Non-game birds	Wild turkey	Bob-white quail	Water-fowl	Mourning dove
Shrubs							
Sumac	X	X	X	X	X		
Yaupon holly	X		X				
Elderberry			X	X			
Serviceberry	X		X	X			
Waxmyrtle			X		X		
Coral berry	X						
Multiflora rose	X		X	X			
Vines							
Blackberry	X	X	X	X			
Greenbriar	X		X				
Wild grape			X	X			
Virginia creeper			X				
Leguminous Forbs							
Common lespedeza	X			X	X		
Korean lespedeza					X		
Partridge pea			X	X	X		X
Cowpea	X			X	X		X
Red clover	X	X		X	X		

Table 1. (Continued)

	White-tailed deer	Cotton-tail rabbit	Non-game birds	Wild turkey	Bob-white quail	Water-fowl	Mourning dove
Sweet clover	X	X		X	X		
White clover	X	X		X	X		
Non-Leguminous Forbs							
Doveweed			X		X		X
Common sunflower			X	X	X		X
Common ragweed			X		X		X
Beggarweed					X		
Spurge							X
Pokeweed			X				X
Knotweed							X
Grasses							
Paspalum			X	X	X		X
Saltgrass						X	
Bromegrass						X	
Panicgrass			X	X		X	X
Bristlegrass				X	X	X	X
Marsh and Aquatic Plants							
Bulrush			X			X	
Pondweeds						X	

Table 1. (Concluded)

	White-tailed deer	Cotton-tail rabbit	Non-game birds	Wild turkey	Bob-white quail	Water-fowl	Mourning dove
Cattails						X	
Smartweeds			X		X	X	
Cordgrass						X	
Spikerush						X	
Chufa						X	
Duckweeds						X	
Japanese millet			X		X	X	X
Cultivated Food and Cover Crops							
Wheat	X		X	X	X	X	X
Barley	X		X		X	X	X
Rice			X			X	
Corn	X		X	X	X	X	X
Oats	X	X	X		X		
Grain sorghum			X	X	X	X	X

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[a] Adapted principally from American Wildlife and Plants, A Guide to Wildlife Food Habits, by Alexander C. Martin, Herbert S. Zim and Arnold L. Nelson, 1951. McGraw-Hill, New York.

cultivated. However, they are included to show their relative value as wildlife food sources.

Cover

Wildlife require hiding places from predators, shelter from the elements, places to bear and raise their young, and travel lanes connecting their feeding and resting areas. It is essential to provide ample cover if wildlife are to inhabit permanently a reclaimed surface mine. For example, bobwhite quail require nesting, loafing, escape, and protective cover near their feeding areas. Low growing woody plants such as multiflora rose, greenbriars, wild plums, etc. frequently provide this loafing and escape cover. However, bobwhites prefer herbaceous cover for nesting sites. Therefore, to establish bobwhite successfully on revegetated surface mined lands will require providing several types of cover.

Water

Some wildlife (e.g., snakes, lizards, squirrels, and rabbits) satisfy their requirements for water from their food. However, most require that running or standing water be available within their home range. Deer require permanent supplies of open water. Waterfowl, muskrats, and raccoons not only need water to meet their metabolic needs, but spend most of their time searching for food in the water or associated riparian vegetation. The strategic location of ponds, marshes, and wetlands on reclaimed surface mines is essential for the maintenance of terrestrial wildlife and increases the diversity of wildlife by meeting the needs of those animals requiring aquatic habitats.

Home Range

The carrying capacity of reclaimed surface mined areas for wildlife is not only a function of the availability of food, cover, and water, but is also governed by the space requirements of the animals. Home range can be thought of as the size of an animal's habitat or living area. The size of the home range depends on the species and is a direct result of behavioral nature, daily and seasonal activity patterns, and movement. The size of the home range is modified by shifts in population density, disturbances, and seasons. For example, the home range of a covey of quail is normally about 0.5 sq mi, while white-tailed deer generally have a home range on the order of 1 sq mi (U.S. Soil Conservation Service 1979a).

Interspersion

Interspersion is the term used to describe the mixture or irregular occurrence of food and cover areas within the home range of a species. Interspersion is very important to the success of wildlife populations. If interspersions (i.e., physical locations and vegetated interconnections) are not carefully planned, an otherwise favorable habitat may not support a viable population of a desired species. Plants which provide food may be located too far from plants providing protective cover. For example, bobwhite quail require loafing cover near the middle of the day. If loafing cover, such as a thicket of yaupon or wild plum, is not present near the feeding area, the quail may not fully utilize available food.

The Edge Principle

The transition zones between open areas and forested areas have long been recognized as excellent habitat for wildlife. These areas receive more sunlight than forested areas, yet do not receive extensive mechanical disturbances from agriculture and thus support a diversity of plants. These plants provide habitat (i.e., food, cover, and space) for wildlife. The "edge principle" states that the more "edge" in a given habitat the greater the variety and abundance of wildlife. For example, the transition zone between a forested area and an improved pasture supports a diversity of songbirds greater than the forest or the improved pasture alone. In planning the revegetation of mined lands, plantings of trees and shrubs in a configuration to give a maximum of edge will increase the overall diversity of wildlife.

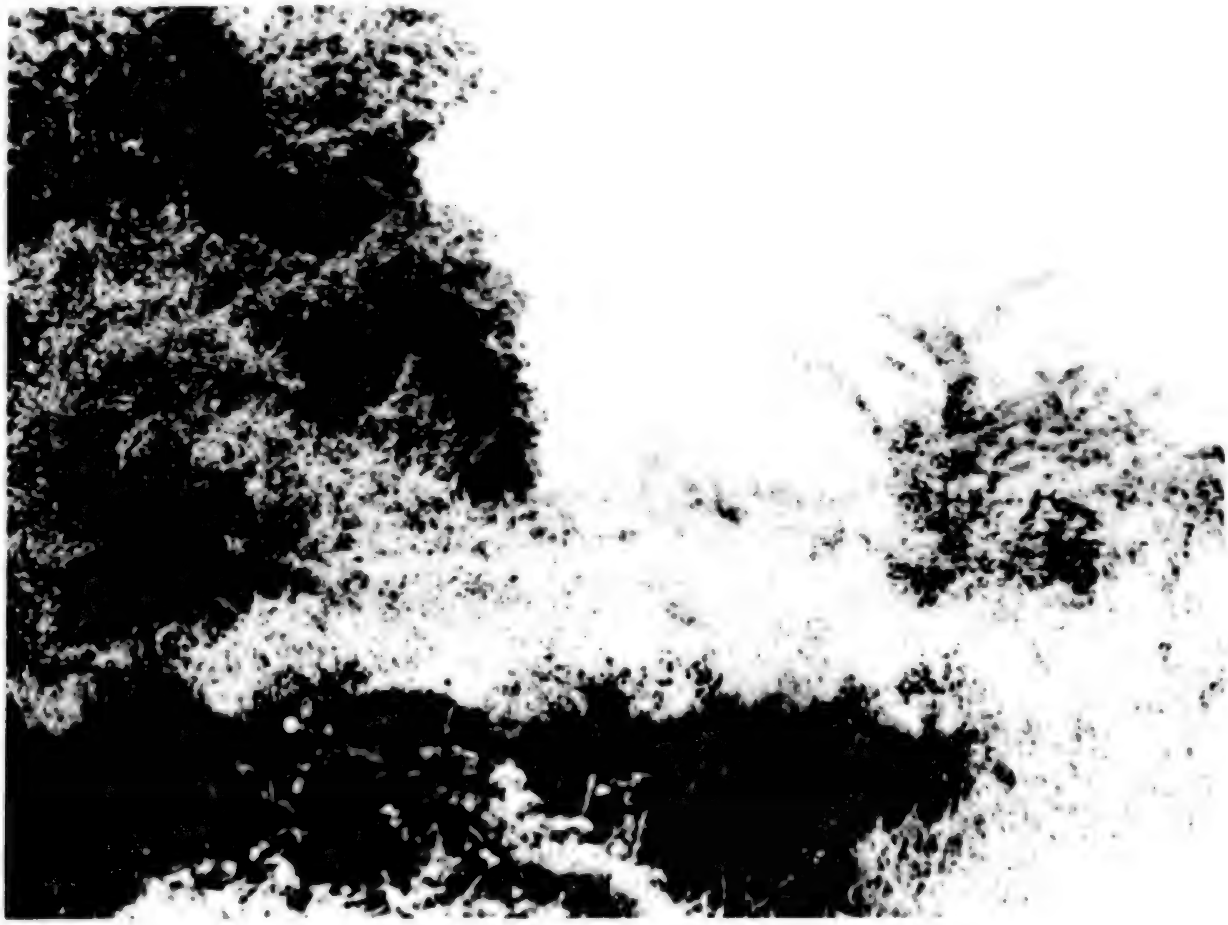

Figure 4. Transition zone between an old field and forested area in the Post Oak Savannah with good interspersion.

ESTABLISHING A MANAGEMENT GOAL

In planning the revegetation of surface mined land for wildlife, it is essential to establish a goal. The kinds of plants used and their pattern of planting may markedly differ depending upon whether the goal is to encourage general wildlife diversity or the enhancement of selected game species.

Long-range reclamation for wildlife is best carried out by utilizing a combination of revegetation practices designed to promote wildlife diversity. Establishing a diversity of habitats which encourages a variety of wildlife (both game and non-game) and allowing succession to take its course is more economical and more ecologically sound than managing a reclaimed area for one or two species of wildlife. However, if lands are to be revegetated to encourage the presence of selected species, consideration of that species' adaptability to the site and the species' food, cover, and water requirements must be made.

Appendix B contains information about the ecological requirements of several Texas and Oklahoma species (white-tailed deer, bobwhite quail, mourning dove, cottontail rabbits, waterfowl, fur-bearing mammals, and non-game birds) frequently associated with surface mined land. If the goal of revetation is to manage for these selected species, Appendix B provides helpful information which may be integrated into the selection of plant materials to be used and the pattern of plantings to be implemented on the site. The appendix also contains some suggested management practices which will assist in maintaining populations of the selected species. Additional management information on other wildlife species not readily associated with the early successional stages of surface mined lands (e.g., squirrels and turkeys) may be obtained from the state wildlife management agencies.

DESIGNING THE REVEGETATION PLAN

Deciding exactly how to revegetate a surface mined land to enhance wildlife depends on the goal of the postmining land use option and the characteristics of the site and its surrounding areas. When considering the type of wildlife enhancement to implement at a site, the capabilities of the site must be considered. A good rule of thumb is to consider managing the site for wildlife which were present on the site or in the immediate area before mining. A planner can rely on information gained in a premining ecological inventory to identify the kinds of wildlife likely to be successfully managed on the site. Likewise, a premining inventory of plants on the site and surrounding area should also be used as a guide in the selection of plant species to be established on the mined area.

A handbook identifying fish and wildlife information needs to surface mine coal has been prepared for Texas and Oklahoma by Hinkle et al. (1980). A model fish and wildlife plan detailing the general content and organization of fish and wildlife information requirements has also been prepared specifically for Oklahoma coal operators (Schnell et al. 1981). These documents, along with this guide, should be utilized in developing site-specific wildlife management features.

Mapping the Premining Land Use

As an aid in planning for revegetation, it is frequently helpful to develop from the baseline ecological inventory a premining land use map of the mine site and adjacent area. The map should show the types and location of vegetation present on the site before it was mined. The map is also useful in identifying the types of plants which were successful at various elevations, moisture contents, and exposures on the site. This information can be helpful in choosing the types of plants and patterns of plantings in the postmining revegetation of the site. Figure 5 illustrates a premining land use map showing the location of various vegetation types for a representative site in the Post Oak Savannah. The distribution of the vegetation reflects previous land use by man (i.e., old abandoned fields and cultivated areas) and to some degree the influence of the exposure, availability of moisture, and location of various soil types. Additional information regarding the mapping of land uses and vegetation may be obtained from Hinkle et al.(1980) and Schnell et al. (1981).

Site Considerations for Revegetation

In developing a revegetation plan for wildlife, specific consideration of the characteristics of the location influences the selection and arrangement of planting. The choice of plantings will be dictated by environmental factors, including:

- The chemistry and physical characteristics of the soil
- Topography of the site
- Exposure--shade from nearby vegetation
- Climate.

Many plants can tolerate a wide variety of environmental conditions and are adapted to all of the vegetation regions where lignite and coal are found in Texas and Oklahoma. For example, red cedar, hickories, post oak, Russian olive, yaupon, and many grasses are adaptable to a wide range of soil pH, exposure, and climatic conditions. Other plants such as the legumes cannot tolerate low pH soils and require amendments such as lime added to the soil. Consultation with county Soil Conservation Service (SCS) offices should provide helpful information with respect to soils and plant adaptability.

Topography of a mine site is also an important consideration in choosing postmining land use options and in developing the site for wildlife. For example, the degree of slope and slope orientation may significantly affect the warmth and/or moisture which plants receive. Table 2 shows the relationship of soil pH and slope to alternative land uses. These guidelines, developed by the SCS for abandoned mine lands in Oklahoma, indicate that a wildlife land use option is applicable to lands in all slope and pH categories.

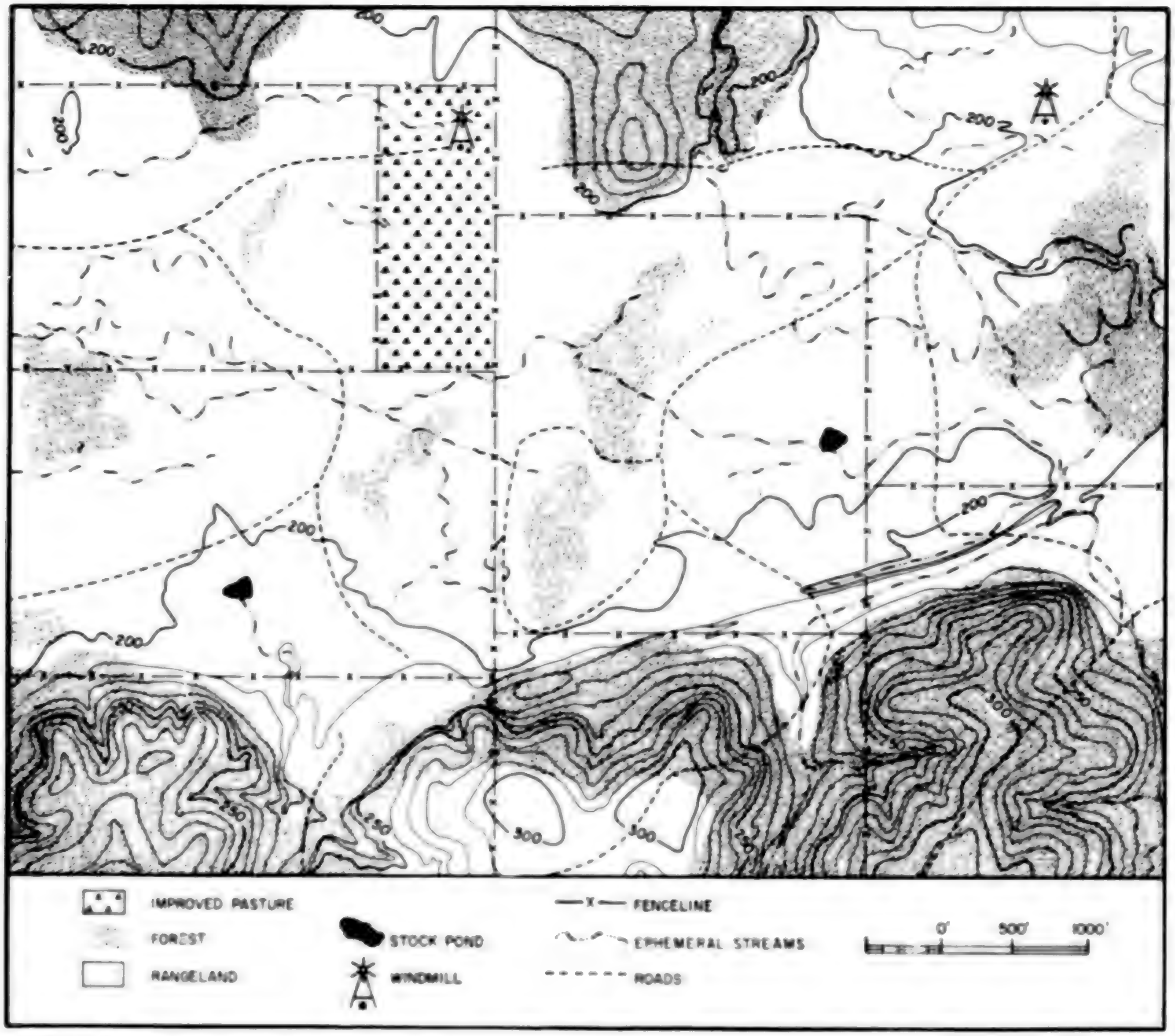

Figure 5. Example of a premining land use map showing the location of forested areas, rangeland, stock ponds, and roads.

Table 2. Relationship of soil pH and slope to alternative land uses.[a]

Soil group	pH	Slope 0-8%	 9-25%	 Over 25%
1	75% of more of the area above pH 5.5	Pastureland Cropland Rangeland Woodland Wildlife Recreation	Pastureland Rangeland Woodland Wildlife Recreation	Woodland Wildlife Recreation
2	Less than 75% of the area above pH 5.5 and at least 75% above pH 4.5	Rangeland Woodland Wildlife Recreation	Rangeland Woodland Wildlife Recreation	Woodland Wildlife Recreation
3	50% of the area or more is pH 4.5 or below and not more than 50% below pH 4.0	Rangeland Woodland Wildlife Recreation	Rangeland Woodland Wildlife Recreation	Woodland Wildlife Recreation
4	More than 50% of spoil area below pH 4.0 but above pH 3.5	Wildlife Recreation	Wildlife Recreation	Wildlife Recreation

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[a] Adapted from State Standards and Specifications for Establishment of Vegetation on Surface Mined Areas. U.S.D.A., Soil Conservation Service, Stillwater, Oklahoma, 1976.

However, low pH soils and steep slopes eliminate the cropland and pastureland land use options. Following stabilization with grasses, steep slopes are excellent sites for trees which provide shelter and food for wildlife species. Furthermore, only trees and shrubs which can tolerate dry conditions should be planted (e.g., post oak, black locust, yaupon, etc.) on these critical sites.

Shade tolerance is another important factor in successful reclamation planting. Some plants do well in full sunlight, but die or quit producing fruit when large trees shade them from the sun. For example, persimmons grow best in full sunlight, but are not as vigorous when shaded. On the other

Figure 6. Persimmons are used by a variety of wildlife as a source of food in the fall.

hand, dogwoods, redbuds, and other understory plants prosper in the shade provided by taller trees. When planning the revegetation of an area for wildlife, consideration should be made of the requirements of the plants at the time of establishment and in the future as the vegetation matures. An appropriate mixture of plantings that provide wildlife food early in the reclamation process and then offer both food and cover as successional regrowth proceeds, is desirable.

Finally, climatic conditions such as the amount of rainfall, extent of hot or cold weather, frost date. etc., must be considered when choosing plants to revegetate surface mined land. Plants to be used in a wildlife revegetation plan should not only be useful as wildlife food and shelter, but should also be adapted to local conditions. Establishment of pines in a prairie environment containing alkaline soils will prove fruitless, just as will the use of coastal bermuda grass for ground cover in northern Oklahoma due to winter kill. Similarly, consideration of the timing of planting is critical to the successful establishment of vegetation. The degree of risk can be minimized by planting during times of the year which are suitable for the species of concern.

Species Suitable for Revegetation to Wildlife Habitat

Reclamation of surface mined spoils for wildlife necessitates the use of those plant species that are particularly important in the development of food, cover, and reproductive habitats. A list of species recommended for revegetating spoils for wildlife is given in Appendix C. The vegetation region to which each plant is adapted, the primary wildlife uses of each plant, and sources of plant stock or seed are included. A list of seed and/or planting stock dealers is also provided in Appendix D.

Because of the wide range of differences in climate, soil, and topography in the three vegetation regions of interest in the Texas-Oklahoma area, specific cultivars have not been recommended. Information about those cultivars best suited to a particular site can be obtained from local SCS and County Agricultural Extension personnel. Obviously, the recommended list of species is not exhaustive since almost any vegetation has some value for wildlife. For example, common weeds such as ragweed, pokeweed, crabgrass, smart weeds, panic grasses, etc., which often proliferate voluntarily on surface mined soils, should be encouraged in select areas as good food sources for wildlife.

A number of wild plants native to East Texas and Oklahoma are excellent for wildlife, but usually are not readily available as planting or seeding stock. Species of wild blackberries, grapes, and greenbriar are examples of species that may be used in appropriate habitats when planting stock or seeds can be obtained.

A few plants that are excellent for wildlife habitat development should be used with great care and thorough planning (Gill and Healy 1973). For example, multiflora rose is a valuable plant furnishing excellent cover as well as food for wildlife. It should be managed carefully, however, because its extraordinary success in spreading frequently results in its invasion of areas where it is unwanted.

Several of the honeysuckles (*Lonicera* spp.) can also become problematical. These plants are among the best for providing cover for many wildlife species, but they are difficult to control. Because they tend to suppress other plants in the vicinity, they must be used with care.

Much controversy has surrounded the use of black locust (*Robinia pseudoacacia*) for revegetation of surface mined spoils. It is a desirable tree in that it will grow rapidly in almost any soil and under most environmental conditions. Also, its association with nitrogen-reducing bacteria enables it to add nitrogen and organic material to spoils, thus improving them for better support of other species (Finn 1953; Ashby and Baker 1968). The black locust is a fierce competitor that forms dense stands from root sprouts and may smother other desirable vegetation. Careful and innovative management of the species can alleviate potential problems (Ashby et al. 1978); therefore, its inclusion in plantings under appropriate conditions is recommended.

Surface mined lands in Texas and Oklahoma can be successfully revegetated for fish and wildlife. The variability in climate, topography, and soils in the two-state area affects the kinds of plants that can be successfully established; the plants obviously determine the kinds of wildlife populations that can be maintained.

Revegetation in the Pineywoods and Post Oak Savannah Regions is relatively easy due to adequate rainfall and generally moderate temperatures (Garner 1953; White 1978). In the drier southern areas comprising the South Texas Plains Region, environmental extremes are common, and consequently, planning and implementing revegetation efforts will be more difficult.

In the following section, some important reclamation management practices are reviewed. These suggestions stress planning for revegetation that enhances wildlife diversity.

Planting Patterns Beneficial to Wildlife[1]

Some patterns of planting vegetation are, in general, more attractive to wildlife than others. Since diversity is a basic principle behind wildlife management, revegetation techniques that provide a variety of plants and habitat types improve an area for most resident wildlife. For example, strip plantings, border plantings, and clump plantings of woody species in and around open areas planted to grasses are desirable to wildlife because they create more "edges." "Edges" increase food and cover types and provide for better wildlife distribution.

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[1] The authors credit Rafaill and Vogel (1978) and Vogel (1981) for much of the information in this section.

Any revegetated surface mined site can be improved for wildlife with alternating rather than solid plantings of herbs, trees, or shrubs. Strips of grasses and legumes 100 to 150 ft wide alternating with strips of shrubs and/or trees 30 to 50 ft wide would be a useful pattern to plant on expansive sites. Zig-zag patterns will also greatly enhance edge effect on reclaimed sites. Open areas should be at least one-half acre in size.

Basic wildlife management principles can also be incorporated into other land use options. Where area-mined sites are to be revegetated for pasture or crops, tracts of extensive seeding can be diversified by planting a strip, not over 20 ft in width, of shrubs such as bristly locust, autumn olive, or sumac. Strip plantings may also serve as woodland/field borders at the edge of proposed pastures or cropland. Shrubs can be useful as hedges and living fences extending across future croplands or along cropland and pasture boundaries. These hedges usually consist of one or two rows of shrubs laid out on the contour. Two or three rows of red cedar planted along one side of a single row of autumn olive, multiflora rose, or black locust can provide an effective windbreak for a future pasture or cropland while improving nesting, escape, and winter cover for wildlife. One to ten rows of trees and shrubs, or shrubs only, at right angles to the direction of the prevailing winds also provide an effective windbreak. Scattered clump plantings (motts) of trees and shrubs in an open field provide needed food and cover.

Travel lanes for wildlife can be provided by planting one row of a dense growing shrub such as bristly locust or multiflora rose or two rows of shrubs such as wild plum, sericea lespedeza, or honeysuckle. Row plantings, although they may appear artificial, create runways for many ground dwelling birds and mammals. A random planting pattern may be more pleasing to the eye, but it creates gaps in the cover that some birds and mammals are unwilling to cross.

In East Texas, pine tree plantations can be planned that will also benefit wildlife. Proper planning and management will provide harvesting on a continuous, rotating basis. In this way, part of the understory remains unshaded and can develop vegetational variety on the area. A double or single row shrub border spaced 5 ft between rows and planted adjacent to a conifer plantation will further improve the wildlife value of the area.

Mixed forest plantations are best for wildlife. Planting blocks of mixed hardwoods within conifer plantations increases the variety of food and cover types available for wildlife while providing potential wood products. Sections of hardwoods may be separated from coniferous rows by grass/legume strips to provide more edge and open areas. Hardwood timber lots will also be more desirable to wildlife if provided with a double or single row shrub border about 40 ft from the edge of the woods.

In any of the above examples, additional forms of cover may be necessary to increase the general wildlife carrying capacity of the area. Escape cover can be created artificially from boulders, logs, slash, brush, and so forth. Such materials can be piled in odd areas, travel lanes, or other places. Space artificial cover 250 to 300 ft apart when suitable natural cover is lacking.

Food plots also can be planted to help sustain wildlife populations. However, food plots cannot serve as substitutes for permanent food-bearing plants. A food plot is any cultivation of domestic food plants reserved for wild animal usage. Plots should not be less than one-eighth acre in size. Generally, one-eighth to one-half acre patches spaced at one patch per 40 acres minimum are beneficial. Long, narrow food patches near cover are best. Examples of plants commonly used in food plots include rye, wheat, oats, corn, peanuts, millet, partridge pea, and singletary peas.

Planning to establish a desirable mixture of habitat components that will provide the greatest diversity possible is an important concept in wildlife management. The above suggestions are all aimed at creating more "edge" and additional food and cover sources that might otherwise be lacking or inadequate on a revegetated site.

It must be remembered that vegetation changes with time; therefore, the quality and quantity of food and cover, in turn, will be affected. In order to counteract this natural process of change, some maintenance procedures will be necessary. For example, open areas will become overgrown and make cutting, discing, or controlled burning necessary to preserve this cover type. Recommendations for the best maintenance procedures may be obtained from professional wildlife biologists, conservationists, and foresters. Some management practices for selected wildlife species are identified in Appendix B.

Wildlife and Other Land Use Options

Surface mine lands which are being reclaimed to some land use option other than wildlife can incorporate wildlife benefits through establishment of plants providing food and cover and thorough management of the alternative land uses in a way to accrue wildlife benefits. If wildlife is to be a secondary land use goal, food, cover, water, and interspersion must be incorporated into the reclamation plan in order for the land to support wildlife. Several general practices which encourage wildlife productivity have been outlined (U.S. Forest Service 1969, 1971; U.S. Soil Conservation Service 1979b; Hinkle *et al*. 1980; Frentress and Spain 1980). Some of these practices are listed below for several of the more common land use options used on surface mined lands in Texas and Oklahoma:

Land Use Option: CROPLAND

Practices *Helpful* to Wildlife

. Food and cover plantings along fence rows, roads, drainageways
. Integration of legumes with crops
. Liming and fertilizing

- Stripcropping
- Cover crops
- Stubble/mulch tillage
- Delaying mowing of headlands, roadsides, and watercourses until after the nesting season
- Leaving unharvested one-eighth to one-fourth acre of grain next to good cover.

Practices Harmful to Wildlife

- Clean fall plowing
- Mowing of watercourses and headlands before ground-nesting birds have hatched
- Indiscriminant burning of ditchbanks, fence rows, and crop residues.

Land Use Option: PASTURELAND

Practices Helpful to Wildlife

- Food and cover plantings along fence rows, roads, drainageways, and steep slopes
- Grazing within the carrying capacity of the pasture
- Liming and fertilizing
- Reseeding, renovating, or overseeding with legumes
- Building ponds for wildlife and livestock water
- Discing to promote forbs
- Controlled burning.

Practices Harmful to Wildlife

- Uncontrolled burning
- Overgrazing
- Complete clean mowing early in the season.

Land Use Option: RANGELAND

Practices Helpful to Wildlife

- Food and cover plantings along fence row, roads, drainageways, and steep slopes
- Proper grazing and salting
- Watering places for wildlife and livestock
- Reseeding with grasses and legumes
- Adequate cross-fencing
- Partial brush removal.

Practices Harmful to Wildlife

- Overgrazing
- Complete brush removal
- Uncontrolled burning.

Land Use Option: WOODLAND

Practices Helpful to Wildlife

- Protection from unwanted fire and harmful grazing
- Selective cutting in small woodlands
- Leaving den trees when cutting timber
- Piling brush near the edge of the woods
- "Release" cuttings to increase production of acorns, nuts, and other tree seeds useful for wildlife food
- Cutting trees out of woodland borders to increase the growth of shrubs for food and cover
- Creation of "green tree" reservoirs in bottomlands.

Practices Harmful to Wildlife

- Uncontrolled burning and grazing
- Cutting of all den trees.

Land Use Option: RESIDENTIAL AND COMMERCIAL DEVELOPMENT

Practices Helpful to Wildlife

- Planting of shrubs with high wildlife food value
- Providing supplemental food during stress periods
- Retaining watercourses with streamside vegetation
- Planting a diversity of shrub and tree types to provide cover.

Practices Harmful to Wildlife

- Lack of suitable numbers and types of plantings to provide food and cover
- Close spacing between houses and businesses.

Developing the Revegetation Layout

The first objective of a revegetation plan at a surface mine site should be the stabilization of soils and prevention of erosion. The planting of cover crops of grasses and legumes should be implemented immediately following regrading of an area. Following stabilization, consideration should be given to the seeding and planting of grasses, shrubs, and trees in a planned manner to provide food and cover for wildlife. The design of these plantings should be determined cognizant of the physical aspects of the site, postmining land use goals, needs of desired wildlife, and future management objectives.

A map with a scale of 1:500 can serve as the base of a wildlife vegetation plan. The location of permanent access roads into the reclaimed site should be drawn on the base map. If the site is to have a pond, its location should be identified. Next, it is helpful to locate on the map all sloping lands. These are excellent sites for planting trees and shrubs for food and cover for wildlife. Drainageways should be located and marked as sites for the planting of grasses, trees, and shrubs which grow best in moist areas. A series of symbols identifying different types of trees, shrubs, and grasses is a good way to display the information on the layout map.

It is also useful to examine the land use adjacent to the site and determine if it is reasonable to make plantings to provide interconnections to be used as runways for wildlife, or to provide food plots near cover on adjacent lands. These locations should be indicated on the map. If part of the site is to be used for improved pasture, the location should be identified and plans made to plant shrubs and trees along the fencelines for wildlife habitat. The base map should be examined to determine if additional plantings are needed to provide "edge" and to assure interspersion. If needed, the location of these plantings should be identified on the map.

Newly reclaimed sites frequently lack habitat diversity while the plants are growing and getting established. For this reason, artificial habitats (brush piles, rock piles, etc.) can be placed on the site to provide cover. Their locations should be indicated on the base map. As each item is added to the base map, a picture should emerge showing the distribution and types of habitats to be created by the revegetation program.

This map can serve as a guide for the actual implementation of the revegetation plan by directing workers to the location of plantings. It can also assist in determining the amount of seeds, sprigs, and shrub and tree stock needed to revegetate the area. Since the map is to scale, it is possible to identify the numbers of shrubs and trees to order from suppliers. Guidance on how far apart to plant representative shrubs and trees in order to provide wildlife cover is found in Section 4 or can be acquired from wildlife biologists working for State and Federal wildlife agencies. The SCS can also provide guidance on the recommended types and spacing of various plants used in reclamation.

Figure 7 is an example of a wildlife revegetation plan for a typical site located in the eastern portion of the Post Oak Savannah Region of Texas. Shown is an area of approximately 1000 acres. Mining has occurred in over one half of the area. Area A contains land which has not been mined. Area B has been mined and reclaimed for improved pasture. It has been planted predominantly in coastal bermuda grass and clover and is intensively managed. Area C is the most recently mined land and has been chosen to have a primary land use option of rangeland and a secondary land use option of wildlife management. Area C contains about 300 acres.

In this hypothetical revegetation plan, a decision was made to divide Area C into two management units--rangeland and wildlife. Following regrading, construction of a pond, and addition of appropriate soil amenments (fertilizer and lime), a mixture of rangeland grasses and clovers were sown on the entire 300 acres. On the wildlife management unit, seeds of a

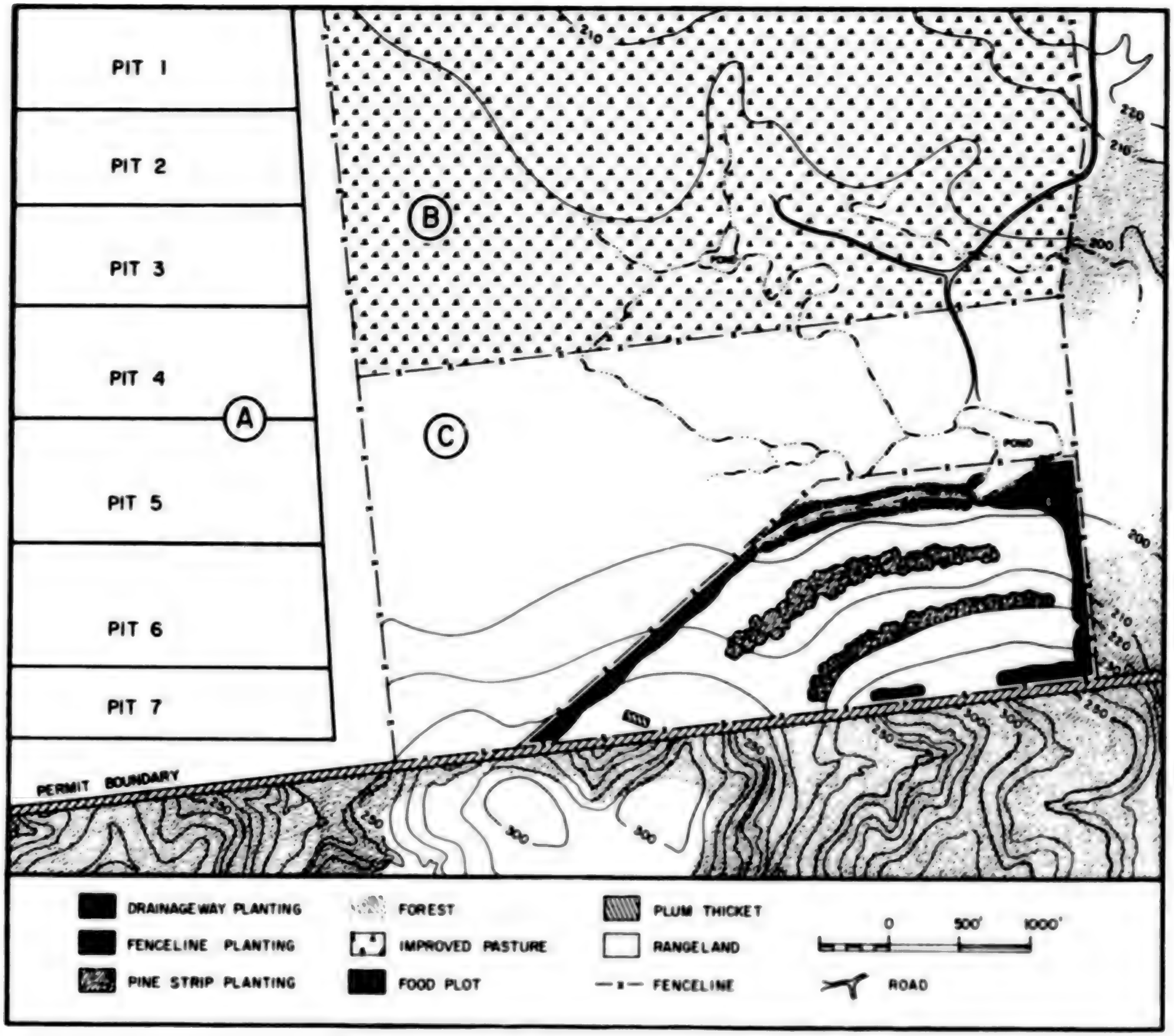

Figure 7. A wildlife revegetation planning map showing the location of fenceline and drainageway plantings, strips, and foodplots.

variety of herbs were also sown including sunflowers, sesbania, sericea lespedeza, partridge pea, and common lespedeza at a rate of approximately 1-2 lbs per acre each.

Boundary fences and cross fences were constructed. The rangeland management unit makes up about 200 acres of Area C. One hundred acres (100) were fenced off as a wildlife management area. The fence prevents overgrazing by allowing appropriate livestock management practices within the wildlife management unit. The wildlife management area was located adjacent to the permit boundary and abutts to adjacent forested lands.

The location of a variety of revegetation management practices which enhance wildlife are illustrated in Figure 7. Following successful establishment of rangeland cover, fenceline plantings of shrubs and trees were made. Fenceline areas were planted with eastern red cedar, black locust, mulberry, osage orange, Russian and autumn olive, sumac, plum, and multiflora rose. A row of eastern red cedar was planted along the fence. Another row of mixed hardwoods was planted approximately 15 ft from the row of eastern red cedar. A row of Russian olives and autumn olives was planted approximately 15 ft from the hardwoods. A mixed row of shrubs (sumac, wild plum, and multiflora rose) was planted adjacent to the row of Russian and autumn olives.

The wildlife plan illustrated in Figure 7 has 4300 linear feet of fenceline where these plantings were made. When established, these fenceline plantings will provide food, cover, travel corridors, edge, and interspersion, which are all critical elements for wildlife.

Additional plantings could be provided if desired, along fencelines and around ponds in the rangeland and tame pasture management units to further enhance wildlife value on these reclaimed sites.

It is possible to calculate the number of plants required along the fencelines in the wildlife plan. Eastern red cedars have a recommended spacing of 6-10 ft. Therefore, for one row along the fenceline, approximately 413 to 717 plants would be required. Since bare-rooted stock was used, the spacing was reduced to the minimum recommended 6 ft to account for possible losses. Thus, 717 eastern red cedars were planted. Similar calculations can be made of how many bare-rooted seedlings are needed for the other plants used in the fenceline planting.

The wildlife plan shown in Area C has 1,000 ft of plantings along a drainageway into the pond. Plants adapted to this area include cottonwood, green ash, Shumard oak, sweetgum, yaupon, and elderberry. In this area, a row of green ash at 8 ft spacings was planted along each side of the drainageway. Adjacent to these was planted a mixed row of yaupon and elderberry. A mixed row of cottonwood, sweetgum, and Shumard oak was planted parallel to the row of shrubs. The spacing between rows was approximately 15 ft. Spacing between trees in a row was 8 ft. Shrubs were placed every 1 ft. This drainageway habitat when fully established should provide additional cover and food for wildlife.

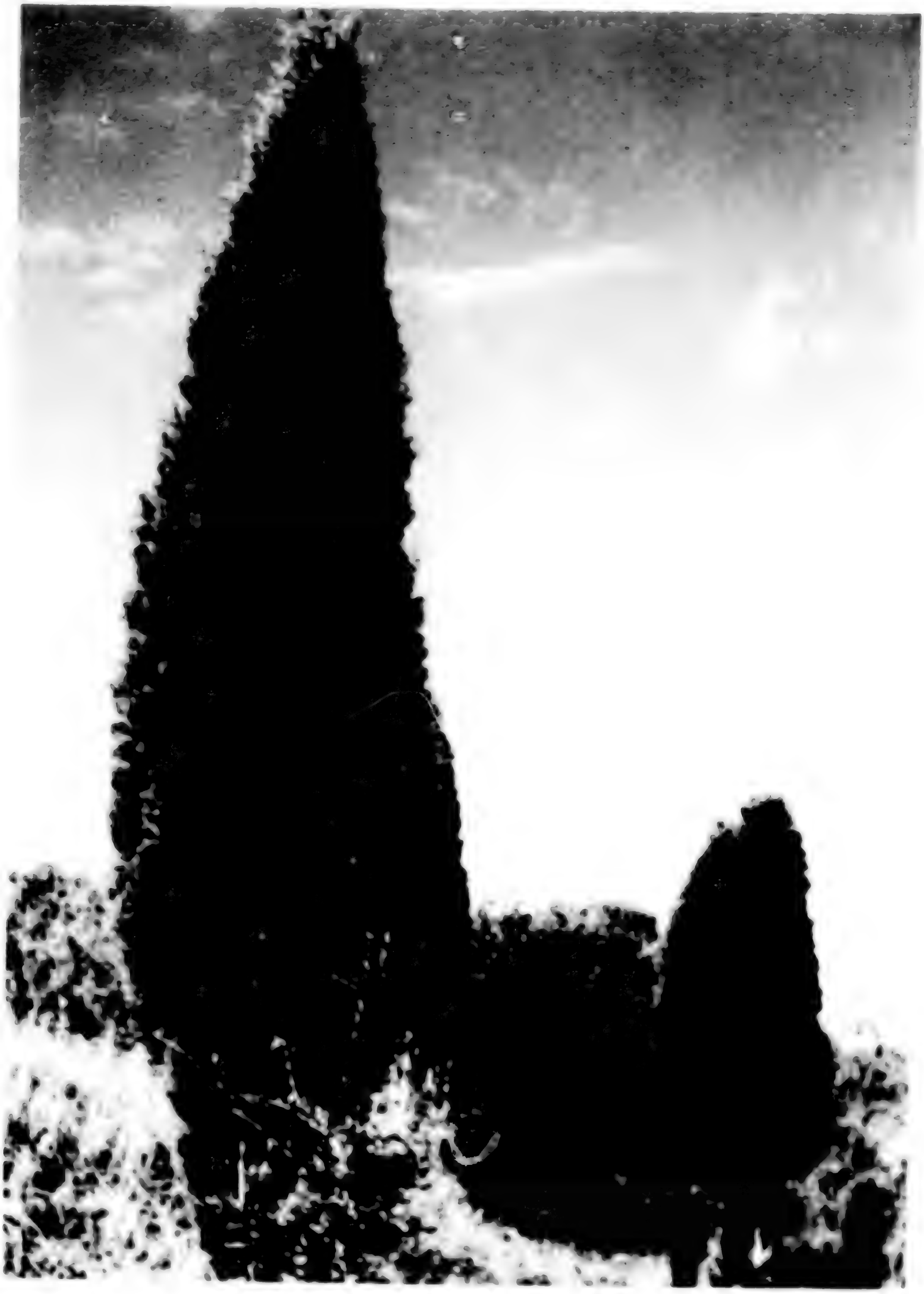

Figure 8. Eastern red cedars are good plants to provide cover along fencelines.

Two evergreen, loblolly pine strip plantings are also shown on the wildlife plan. These strips add habitat diversity, provide a travel corridor for wildlife from the adjacent forested area to the range and pond area, and increase the edge and interspersion of the management unit. The strips total approximately 10 acres in area and were planted at the rate of 1200 trees per acre (6 x 6 ft spacing).

Other wildlife enhancement features illustrated in the wildlife plan include a one-half acre plum thicket, long narrow cultivated plots planted in millet, partridge pea and/or singletary pea mixtures, and waterfowl plantings of Japanese millet around the perimeter of the pond. Establishment of a plum thicket requires the mechanical or hand planting of approximately ten rows, 250 ft long with 4 ft plant spacings. This would require approximately 600 wild plum seedlings. Foodplots require the cultivation of small areas and seeding. These foodplots increase utilization of the area by game birds like quail and dove. Deer also frequently feed on foodplots. Japanese millet planted adjacent to the pond will serve as food for migratory waterfowl.

The wildlife management plan outlined in Figure 7 if implemented should establish food, cover, and water, and therefore, essential habitat elements for successful management of wildlife. The site will undergo a succession of changes as the plants mature and natural invasion occurs. This process will create a diversity of habitats attracting a variety of game and nongame wildlife.

Implementing the Revegetation Plan

After securing approval of the postmining land use plan from the appropriate regulatory authority, implementation of the plan must begin. This requires careful coordination to ensure that plant stocks are available from suppliers when needed and are available for planting at the right times of year. Frequently it is necessary to place orders for plant stocks a year or more in advance to give the nursery time to raise or secure adequate plant materials. If possible, plant stocks which are locally adapted are preferred since they will be more likely to be successful upon planting. Irrigation and selective watering of transplanted materials, as well as the use of mulches, may be necessary until plants get established. It is advisable to have the reclaimed area fenced to prevent cattle from grazing or stomping newly established plants.

Revegetating a mined land requires more than just making the initial plantings. It frequently requires follow-up management to assist the plants in getting established. However, the planning and hard work of revegetating surface mined lands for wildlife is rewarded as the diversity of plants and animals increase, bringing with them the aesthetics and enjoyment of nature.

Figure 9. Pokeweed is a favorite food for many birds.

4. METHODS OF ESTABLISHING VEGETATION FOR WILDLIFE USE

To aid those responsible for revegetating surface mined lands in Texas and Oklahoma, a brief discussion of the various methods of propagation, establishment, and maintenance of plants suitable for wildlife use in this two-state area is included in this section.

In this guide, the plants recommended for revegetation have been systematically divided into the general groups of coniferous trees, hardwood trees, shrubs, vines, leguminous forbs, non-leguminous forbs, grasses, marsh and aquatic plants, and cultivated crop and cover plants. However, for consideration of procedures for establishing these plants, they may conveniently be divided into two major groups: (1) herbaceous species, annual or biennial, which usually are seeded directly on site, and (2) woody species (trees, shrubs, and vines) which usually are planted on site as seedlings or rooted cuttings acquired from nurseries.

Land Preparation for Revegetation

All surface mined soils have been drastically disturbed both physically and chemically. Therefore, management practices must be implemented to ensure that these soils will not be further degraded. More importantly, if these mined soils are to be successfully reclaimed, sound revegetation plans must be formulated and followed. Although each major vegetation region in the Texas-Oklahoma area has its own characteristic climate, soils, and topography, certain general characteristics of the overburden and soils appear to be similar throughout the entire area.

In both states, regulations require that all overburdens be restored to the approximate original contours and drainage patterns unless alternatives are specifically approved by the regulatory authority. The process by which these operations are accomplished are not discussed in this guide. A number of studies have been done to assess the effects of grading and shaping or contouring on soil compaction, bulk density, infiltration, and the ultimate consequences of these factors on the establishment and growth of herbaceous and woody vegetation (Chapman 1967; Howland 1973; Smith et al. 1976; U.S. Forest Service 1979b; Hons 1976, 1978, 1980).

The discussion of methods for establishing plants suitable for wildlife will assume that the spoils have been prepared (i.e. graded and contoured with proper placement of topsoil and toxic materials) for revegetation. It is also assumed that revegetation programs will be within the specifications as detailed for Texas (U.S. Soil Conservation Service 1977, 1981) and

Oklahoma (U.S. Soil Conservation Service 1976). These publications, as well as other regional SCS guidelines, include valuable data related to species selection, establishment, and use. Some of these topics will be referred to in the following discussions.

In Texas, topsoil usually is not segregated during the mining operation (Radian Corp. 1978). Various studies of relatively short duration have shown that mixed overburdens may provide suitable substrates for vegetation as long as toxic materials, especially pyrites, are buried below the root zone (Angel 1973; Askenasy 1977; Gavande et al. 1979; Brown and Deuel 1980). This is because most of the soil overlying the lignite deposits consists of a thin sandy to sandy-loam surface over a rather dense clayey (i.e., claypan) layer. Sandy to clayey soils do not have good tilth, and the moisture relationships are usually not good. Consequently, these aspects of the soil may be improved by the surface mining disturbances.

An exception to the use of mixed overburdens is mandated in those areas involving prime agricultural land or the drier areas of Central and South Texas containing unsuitable overburden materials. A mixed overburden may also have a greater erosion potential and probably a less desirable soil structure than undisturbed soil (Gavande et al. 1979). Specific approval must be obtained from the appropriate regulatory authority to utilize mixed overburdens during revegetation activities.

The overburden materials associated with the bituminous coal deposits of Oklahoma generally contain more shale and thus provide undesirable substrate for revegetation (Doerr 1961). Therefore, the practice of segregating topsoil during mining to be reapplied during reclamation activities is mandated in Oklahoma (U.S. Soil Conservation Service 1976).

The major problem encountered in the use of mixed overburden is the formation of acidity. Acidity is caused by the oxidation of pyritic sulfur that has been exposed to surface conditions. Fortunately, the pyrite content of most soils overlying the coal seams in Texas is low, and the problem of acidity is not unmanageable. Materials from some overburden may become quite acid, however, and require the application of very large quantities of lime to neutralize them (Maloney 1941). This practice is not only expensive, but it can easily result in marked disturbances in the balance and availability of plant nutrients. Pyrite layers, usually, but not always, found just above the lignite and coal seams, should be analyzed to determine their potential for acidification. If the acidification potential indicates some possible problems, selective placement of the overburden should be made to ensure that pyrites are buried well below the level of root growth.

Concentration of heavy metals such as lead, zinc, chromium, copper, and arsenic in the mixed overburden are usually within the range and normal concentrations for native soils (Brown and Deuel 1980). Mixed overburden is slightly alkaline (Gavande et al. 1979); therefore, as long as the spoils are properly limed to prevent acidification, no problems with plant or animal toxicity should occur. Acidification of the spoils must be prevented because the metals become more soluble in an acid environment and, therefore, more available to plants and animals.

Chemical analyses have shown that overburden materials in the Texas-Oklahoma area generally contain adequate concentrations of all essential nutrient elements for plants except phosphorus and nitrogen. The amount of phosphorus and nitrogen required will depend on the plants to be established and, of course, their existing concentration in the spoil.

Native soils in the eastern parts of Texas and Oklahoma support grasses for improved pastureland or hay, but they are much more suitable for native rangelands and woodlands. Surface mined land, when properly restored, often supports plants commonly used for improved pasturelands and hay more successfully than undisturbed soil due to an improvement in soil water retention, texture, and general tilth. However, land reclaimed to coastal bermuda, for example, requires the regular application of large quantities of nitrogen and phosphorus; introduced legumes require relatively large amounts of phosphorus and, in some cases, potassium. If the introduced plants, especially monocultures, are to be successful over a long period, they must be intensely managed; and this may become very expensive. Consequently land owners and land planners should seriously consider the benefits of revegetating with native plants as an alternative to improved pastureland.

It is fortunate that surface mined lands in Texas and Oklahoma can be relatively easily revegetated because of factors such as adequate rainfall, rather flat terrain, moderate temperatures, and favorable soil and overburden characteristics. However, good management practices must be strictly adhered to if successful reclamation is to be achieved.

PLANT SELECTION

Regardless of the ultimate goal or objective of the reclamation program, the plants to be used in revegetation must have requirements compatible with the local environment as well as being suited for the development objective of the site. Exotic species rarely are wise choices. Species indigenous to the local area are much more likely to be successful because they will be adapted to local climatic conditions. Care must also be taken to ensure that the selected plants are compatible with the chemical and physical characteristics of the spoil materials to be revegetated (Clark 1954; Bryson 1973; Grandt 1977; U.S. Forest Service 1979a).

Suggested are those plants having ecological and physiological requirements that make them likely candidates for successful establishment in the vegetation regions for which they are adapted. Numerous species not mentioned in this manual may be excellent choices for revegetating a particular site. Reclamation planners should consult with local SCS and wildlife management personnel before determining what plants to use on a site. Most importantly, SCS Plant Materials Specialists can furnish the names of particular cultivars that will be best suited for a given site. Other excellent sources of information, advice, and help in addition to the regional SCS Plant Materials Specialists are local county extension agents. Appendix A lists the addresses of several sources of technical assistance and information regarding revegetation of surface mined lands.

ESTABLISHMENT OF HERBACEOUS SPECIES

Seed Sources

Seeds of many herbaceous plants commonly used by wildlife can be purchased from commercial dealers. A list of seed dealers and their addresses is given in Appendix D. Other similar lists may be obtained from the SCS, the Forest Service, Texas Parks and Wildlife Department, and some local universities.

Arrangements should be made for the purchase of seed well in advance of their need to ensure availability. Also, it is wise to obtain the seed source and germination test results completed by official seed-testing laboratories for each batch of seed purchased. The source of seed is very important, sometimes critical, since plants may be well adapted to local conditions but not to conditions of another area. Therefore, always obtain seed from a local or nearby source when possible. Once acquired, place seeds in a closed container and keep them refrigerated until they are treated and/or planted (Chandler 1980).

Seedbed Preparation

The success or failure of any revegetation program may well depend on preparation of the seedbed. Reclamation planners are advised to consult with local SCS personnel about methods to prepare seedbeds to best conform to local factors such as climate, soil, and intended usage.

Most mine spoils require some type of mechanical tilling to properly prepare a seedbed. It is most advisable to have the spoils initially graded to contours that will permit the use of standard agricultural equipment in all subsequent operations, beginning with the preparation of the seedbed. Seedbeds may generally be prepared by discing or chiseling. In any case, deep tillage (i.e., at least 6 inches) should be undertaken to ensure maximum moisture retention.

Seed Treatment

Pretreatment of seeds with a fungicide is a fairly common practice and one recommended to ensure better, more rapid establishment of vegetation. Leguminous forbs must be inoculated with the proper bacterium immediately prior to sowing. Seed dealers can supply the correct bacterial inoculant, and some dealers will be able to supply pre-inoculated seed. If seeds are to be sown with a hydroseeder, great care must be taken to keep the pH of the slurry about 5.0 and to spread the slurry in the shortest possible time to prevent killing the bacterial inoculant which is sensitive to low pH. The addition of hydrated lime (up to 10 percent, weight to volume) to the slurry will usually neutralize the slurry.

The seeds of some plants have hard, moisture-impervious seed coats and require treatment prior to sowing to ensure good germination. The process of scarification can be employed to soften the seed coat, make it more permeable to water, and increase its germination potential. Scarification can be done physically by abrasion or chemically with sulfuric acid.

Germination is induced (or at least enhanced) in the seeds of many plants including some grasses such as switchgrass by stratification. Stratification involves treating the seeds with a low temperature (about 40°F/5°C) for 30-60 days. During the cold treatment, the seeds are mixed with sand, sawdust, or moss in a ratio of 3:5 (inert material:seed) contained in a closed container (Schopmeyer 1974). The seed dealer from whom seeds are purchased should be requested to furnish information regarding any pretreatments required and methods for accomplishing the treatments.

Seeding Techniques

Seeds are sown by broadcasting and/or drilling. Each method has advantages and disadvantages and each is more applicable to certain situations than others. Consequently, one method is not necessarily more effective or desirable than the other; local conditions will dictate the method of choice.

Drilling is the common practice on those areas that are readily accessible by farm machinery. Various types and sizes of drills are available. On spoils that are relatively free of rocks, grain drills or grassland drills are used. Rangeland drills are used on rocky, rough spoils. For very small grass seeds, the Brillion seeder and culti-packer is exceptionally useful. Because drilled seeds are placed in the soil and covered, they are exposed to a microenvironment favorable to germination and early seedling growth. Also, fewer seeds are required when drilling is used as opposed to broadcasting.

Broadcasting seeds is necessary on those areas where drills cannot be used and is the method of choice in many other situations. Seeds can be sown dry by various kinds and sizes of broadcast seeders. Such seeders range from small, hand-operated broadcasters to large, tractor-powered machines. Other equipment such as fertilizer or lime spreaders may be used to broadcast seeds, but it is difficult to accurately calibrate the dispersal of seeds from these spreaders. Broadcast seeding is much faster than drilling, and one can broadcast seed over a wide range of soil conditions. Broadcast seeding should be done on well-prepared seedbeds if results comparable to drill-seeding is to be expected.

In those areas where steep slopes are prevalent, the use of hydroseeders is quite advantageous. A major advantage of using a hydroseeder is that seed, fertilizer, hydrated lime, and mulch is mixed to form a slurry that is applied in a single operation. Major disadvantages of a

Figure 10. The seeds of many grasses are used as food by wildlife.

hydroseeder are that a water source is required, a considerable amount of time is needed to refill the tank, and it is expensive. Also, the abrasive action of the slurry agitation system may damage some soft-coated seeds; of course, the germination of some hard-coated legume seeds may be enhanced due to scarification.

Regardless of how seeds are sown, they must be covered to ensure maximum germination and subsequent establishment of the seedlings. This process can be time consuming, expensive and, on very rocky soil or steep slopes, almost impossible. Therefore, the reclamation planner must have a thorough understanding of all pertinent factors before deciding on the seeding methods to be used.

Seeding Mixtures

Surface mined lands must be revegetated as soon as possible after the mining operation to minimize soil erosion. State and Federal regulations require revegetation that will limit the amount of rill erosion and reduce the amount of sediments in the water from the mined area. Because of this requirement, most mined lands in Texas and Oklahoma are initially revegetated to herbaceous species that establish quickly and provide satisfactory ground cover in a minimum of time.

Numerous possibilities exist for revegetation with different seeding mixtures of herbaceous species. Good wildlife mixtures should contain at least three to five perennial grasses, three to five perennial legumes, and two forbs (U.S. Soil Conservation Service 1981). The perennial grasses selected usually are those that grow well in the area and need a minimum amount of maintenance, including fertilizer, for continued growth after their establishment. The legumes are included to furnish nitrogen to the soil thereby eliminating, or at least lessening, the need for repeated applications of nitrogen fertilizer.

Local situations will dictate the actual seeding mixture to be used. Therefore, the selection of seeding mixtures should be made in consultation with local SCS plant material specialists, wildlife management biologists, or technical guidance materials published by appropriate agencies whenever available. Some examples of herbaceous species which can be utilized in seed mixtures for each of the three major vegetation regions of Texas and Oklahoma are given in Tables 3-6. Also provided are the recommended planting dates and seeding rates for these species. The planting dates shown are not binding to the exact time period since they will fluctuate several days either way depending on weather conditions, elevation, and latitude. Seeding rates should be adjusted proportionately when mixtures of herbaceous species are planted. Planting depths for herbaceous species generally range from one-fourth to three-fourths inch, but may also vary according to climatic, soil, and plant species characteristics.

Table 3. Permanent herbaceous mixtures and planting techniques recommended for the establishment of wildlife habitat in the Pineywoods vegetation region of East Texas.[a]

Species	Seeding rates (lb/ac)[b]	Planting dates
Grasses		
Bahiagrass	20.0 PLS[c]	10/1 - 5/15
Bluestem mixture	6.8 PLS	2/1 - 4/30
Dallisgrass	7.0 PLS	2/1 - 4/30
Indiangrass	9.0 PLS	2/1 - 4/30
Kleingrass	4.0 PLS	3/1 - 5/31
Switchgrass	7.0 PLS	2/15 - 5/15
Tall fescue	12.0 PLS	9/15 - 11/30
Weeping lovegrass	4.0 PLS	3/1 - 5/31
Forbs		
Common sunflower	3.0 CM[c]	3/15 - 6/1
Maximilian sunflower	16.0 PLS	3/1 - 4/30
Legumes		
Arrowleaf clover	6.0 CM	9/15 - 11/30
Crimson clover	20.0 CM	9/15 - 11/30
Partridge pea	20.0 CM	3/1 - 4/30
Sericea lespedeza	30.0 CM	3/1 - 4/15
Sesbania	30.0 CM	3/1 - 4/30
Singletary pea	25.0 CM	9/15 - 11/30
Vetch	10.0 CM	9/1 - 11/30

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[a] Adapted from U.S. Soil Conservation Service 1977, 1979b, 1980, 1981.

[b] Where mixtures of species are seeded, rates should be adjusted proportionately. All seeds may be drilled or broadcasted.

[c] PLS = Pure Live Seed; CM = Commercial Seed.

Table 4. Permanent herbaceous mixtures and planting techniques recommended for the establishment of wildlife habitat in the Post Oak Savannah vegetation region of Texas.[a]

Species	Seeding rates (lb/ac)[b]		Planting dates
Grasses			
Bahiagrass	20.0	PLS[c]	9/15 - 5/15
Bluestem mixture	6.8	PLS	2/1 - 5/15
Buffalograss	20.0	PLS	2/1 - 5/15
Dallisgrass	7.0	PLS	2/1 - 4/30
Green sprangletop	3.4	PLS	3/1 - 5/15
Indiangrass	9.0	PLS	3/1 - 5/15
Kleingrass	4.0	PLS	3/1 - 5/15
Sideoats grama	11.0	PLS	3/15 - 5/15
Switchgrass	7.0	PLS	3/1 - 5/15
Vine mesquite	12.0	PLS	3/15 - 5/15
Weeping lovegrass	4.0	PLS	4/1 - 5/15
Forbs			
Bush sunflower	10.0	PLS	3/15 - 5/30
Common sunflower	3.0	CM[c]	3/15 - 6/1
Engelmann daisy	1.0	PLS	9/1 - 2/30
Maximilian sunflower	16.0	PLS	3/1 - 4/30
Legumes			
Arrowleaf clover	6.0	CM	9/15 - 11/30
Crimson clover	20.0	CM	9/15 - 11/30
Partridge pea	20.0	CM	3/1 - 4/30
Sericea lespedeza	20.0	CM	3/1 - 4/15
Sesbania	30.0	CM	4/15 - 6/15

Table 4. (Concluded)

Species	Seeding rates (lb/ac)[b]	Planting dates
Singletary pea	25.0 CM	9/15 - 11/30
Sweetclover	15.0 CM	9/1 - 10/31
Vetch	10.0 CM	9/1 - 11/30

[a] Adapted from U.S. Soil Conservation Service 1977, 1979b, 1980, 1981.
[b] Where mixtures of species are seeded, rates should be adjusted proportionately. All seeds may be drilled or broadcasted.
[c] PLS = Pure Live Seed; CM = Commercial Seed.

Table 5. Permanent herbaceous mixtures and planting techniques recommended for the establishment of wildlife habitat in the Post Oak Savannah vegetation region of Oklahoma.[a]

Species	Seeding rates (lb/ac)[b]		Planting dates
Grasses			
Bahiagrass	20.0	PLS[c]	3/1 - 6/30 8/1 - 9/30
Big bluestem	10.0	PLS	12/1 - 5/15
Indiangrass	10.0	PLS	12/1 - 5/15
Little bluestem	10.0	PLS	12/1 - 5/15
Smooth bromegrass	25.0	PLS	9/1 - 10/31
Switchgrass	8.0	PLS	12/1 - 5/15
Tall fescue	20.0	PLS	9/1 - 10/31
Weeping lovegrass	6.0	PLS	4/1 - 6/15
Forbs			
Common sunflower	3.0	CM[c]	3/15 - 6/1
Maximilian sunflower	2.0	PLS	3/1 - 6/15
Legumes			
Arrowleaf clover	5.0	PLS	9/1 - 10/31
Crimson clover	15.0	PLS	9/1 - 10/31
Crownvetch	5.0	PLS	9/1 - 10/31
Red clover	5.0	PLS	9/1 - 10/31
Sericea lespedeza	30.0	PLS	3/1 - 5/15
Sweetclover	15.0	PLS	9/1 - 10/31
Vetch	15.0	PLS	9/1 - 10/31

[a] Adapted from U.S. Soil Conservation Service 1976 and unpublished Oklahoma SCS planning documents.

[b] Where mixtures of species are seeded, rates should be adjusted proportionately. All seeds may be drilled or broadcasted.

[c] PLS = Pure Live Seed; CM = Commercial seed.

Table 6. Permanent herbaceous mixtures and planting techniques recommended for the establishment of wildlife habitat in the South Texas Plains vegetation region.[a]

Species	Seeding rates (lb/ac)[b]	Planting dates
Grasses		
Alkali sacaton	2.0 PLS[c]	2/15 - 3/15, 8/15 - 9/15
Big bluestem	12.0 PLS	2/15 - 3/15
Buffelgrass	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Green sprangletop	3.4 PLS	2/15 - 3/15, 8/15 - 9/15
Indiangrass	9.0 PLS	2/15 - 3/15
Kleberg bluestem	2.4 PLS	2/15 - 3/15, 8/15 - 9/15
Kleingrass	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Lehmann lovegrass	4.0 PLS	2/15 - 3/15, 8/15 - 9/15
Plains bristlegrass	6.0 PLS	2/15 - 3/15, 8/15 - 9/15
Sideoats grama	11.0 PLS	2/15 - 3/15, 8/15 - 9/15
Switchgrass	7.0 PLS	2/15 - 3/15, 8/15 - 9/15
Trichloris	2.4 PLS	2/15 - 3/15, 8/15 - 9/15
Forbs		
Bush sunflower	1.0 CM[c]	3/15 - 6/1
Common sunflower	3.0 CM	3/15 - 6/1
Engelmann daisy	1.0 PLS	3/1 - 5/15, 9/1 - 2/30
Maximilian sunflower	16.0 PLS	3/15 - 6/1

Table 6. (Concluded)

Species	Seeding rates (1 lb/ac)[b]	Planting dates
Legumes		
Sesbania	30.0 CM	4/15 - 6/15
Sweetclover	15.0 CM	2/15 - 3/15, 9/1 - 11/30
White clover	5.0 CM	9/1 - 11/30

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[a] Adapted from U.S. Soil Conservation Service 1977, 1979b, 1980, 1981.

[b] Where mixtures of species are seeded, rates should be adjusted proportionately. All seeds may be drilled or broadcasted.

[c] PLS = Pure Live Seed; CM = Commercial Seed.

Fertilization and Maintenance ctices

Prior to sowing or planting on a reclamation site, adequate soil tests should be made to determine what must be done to the soil so that it meets the requirements of the desired plants. Obviously, these tests will indicate conditions unfavorable for many plants, thereby narrowing the selection of plants for the site. Most agricultural schools such as Texas A&M University and Oklahoma State University will analyze soil samples for a modest fee; numerous commercial companies also analyze soils.

Newly prepared seedbeds of surface mined soils have virtually no organic matter and have little, if any, nitrogen. Consequently, the establishment of a vegetative cover will necessitate the application of nitrogen. Whenever logistics and costs permit, nitrogen should be applied in split applications. Legumes should also be included in reclamation plantings as a nitrogen source and to aid in the addition of organic matter to the soil.

Phosphorus tests should indicate both available and residual phosphorus. Since little information is available concerning the amount of phosphorus required on spoils, yields from plots fertilized according to recommended levels should be measured over several years to determine if single or multiple applications are needed to support the plants being grown (Barnhisel 1977). Phosphorus may pose particular problems in a spoil because of varying pH conditions. Residual phosphorus may be much more readily released in some areas than in others; therefore, monitoring available phosphorus levels over time is required.

Potassium may be deficient in sandy soils. Limited data indicate the more shaley soils contain adequate amounts of available potassium. Soil tests will indicate how much, if any, potassium should be added to the soil.

Virtually all surface mined lands are acidic and require the addition of lime. Any addition of lime should be based on test results of both active acidity and total potential acidity. It is important to incorporate the lime into the soil so that the root zone will be as deep as possible.

The actual application of fertilizers may be made in numerous ways including bulk truck spreaders, bulk tractor spreaders, aerial application, hydroseeders, and special fertilizer attachments on planters or other equipment. On small areas and areas not accessible to farm machinery, fertilizers may be spread manually, using some type of cyclone spreader.

ESTABLISHING WOODY SPECIES

Mine spoils to be revegetated for wildlife habitats usually will be planted with combinations of herbaceous and woody species. The specific combination of species to be planted will depend on numerous site conditions, as well as on the kinds of wildlife to be encouraged (U.S. Soil Conservation Service 1980; Texas Agricultural Extension Service 1980). The actual planting patterns that would be beneficial to wildlife are discussed in Section 3 of this guide. Generally, the area to be reclaimed for wildlife use should contain at least 450 stems per acre of woody stock (trees and shrubs) on a minimum of 25 percent of the acreage being reclaimed. Where wildlife is a highly desired secondary land use, at least 10 percent of the site should be reclaimed in woody vegetation (U.S. Soil Conservation Service 1981).

Revegetation of woody species can be accomplished with seeds, seedlings and/or vegetative cuttings. In some instances where a more mature woody cover is desired, it may be possible to transplant larger woody species from undisturbed areas by means of a tree spade or front-end loader (Frizzell et. al. 1980; Larson 1980). Each of these three methods will be briefly considered in this section.

Seeds

Seeds of many woody plants recommended for wildlife habitats in Texas and Oklahoma can be obtained from commercial dealers (Appendix D). In most cases, seed is the least expensive plant material available. However, the attractive initial cost often is counterbalanced by the fact that the seeds must be germinated into seedlings which are then planted or they must be direct-seeded on the site.

The preceeding discussions concerning the availability, adaptability, and establishment of herbaceous seeds is applicable to seeds of woody plants as well and will not be repeated. The following paragraphs are concerned with some factors peculiar to seeds of woody plants (trees, shrubs, and vines).

Direct-seeding of trees and shrubs has become more popular in recent years, especially on steep slopes and areas of limited accessibility. Unfortunately, only a few data are available to suggest the best procedures to follow to ensure maximum success. Nevertheless, a number of species have been successfully established through direct-seeding on diverse sites. Rafaill and Vogel (1978) list several species that have been successfully established by direct-seeding especially in the South and Southeast. Those species that may be successfully established by direct-seeding and are adaptable in Texas and Oklahoma include black locust (*Robinia pseudoacacia*), loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), virginia pine (*Pinus virginiana*), green ash (*Fraxinus pennsylvanica*), shrub lespedeza (*Lespedeza bicolor*), indigobush (*Amorpha fruticosa*), and autumn olive (*Elaeagnus umbellata*).

Seed treatment with bird, rodent, and insect repellants has markedly increased the success of direct-seeding (Chandler 1980). The addition of a mycorrhizal inoculant, especially for pines, is advised. Since the success of direct-seeding depends on so many variables, and since the effect of most variables are poorly understood, it is imperative to work closely with experienced direct-seeders as suggested by Chandler.

If seeds are to be germinated prior to outplanting, a nursery must be available. Chandler (1980) discusses several points concerning the establishment of a seed nursery and subsequent procedures required to germinate seeds and successfully develop them into seedlings. Growing seedlings in containers for later outplanting is an increasingly used method, but it will continue only as a supplement to bare-root production because of increased costs (Barnett 1980). Nevertheless, the use of containerized seedlings should be considered, especially for those sites that are rough, rocky, and difficult to direct-seed.

Seedlings

By far the most common means of establishing woody plants is through the use of seedlings. Desired seedlings can be grown in on-site nurseries or purchased from commercial nurseries (Appendix D). Seedlings, especially for pines, should be purchased locally whenever possible due to their adaptability and susceptibility to certain diseases (Wells 1969). It is often necessary to order seedlings a year or more in advance of the planting date; therefore, thorough advance planning is required.

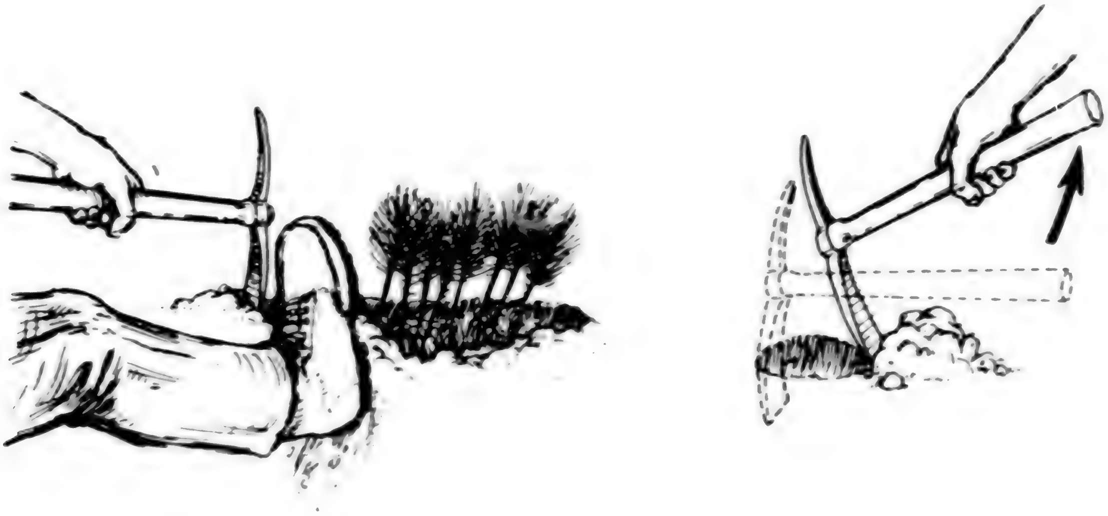
Seedlings shipped from commercial nurseries are perishable and must be carefully handled upon receipt. If seedlings must be stored, they should be placed in refrigeration at a temperature of 35-40°F (2-5°C). Prior to refrigeration, be sure the roots are wrapped in a mulch and well watered. When seedlings are removed from refrigeration, it is imperative that they be protected from desiccation. They should be kept moist, shaded, and out of the wind. Never allow the roots to become dry.

An alternative method of holding seedlings until they can be outplanted is by "heeling-in". When space is available, this method usually is more feasible than refrigeration. To heel-in seedlings, a V-shaped trench is dug in a shaded piece of land. Seedlings are spread out in the trench and covered with loose soil to a depth sufficient to cover the stems a little higher than the root system (Figure 11). The loosely-filled trench is now watered thoroughly, and the process is completed by filling in soil and tamping it down to firm it and remove large air spaces that may have formed. It is imperative to keep the seedlings moist, not wet, until they are planted in the field.

Cuttings

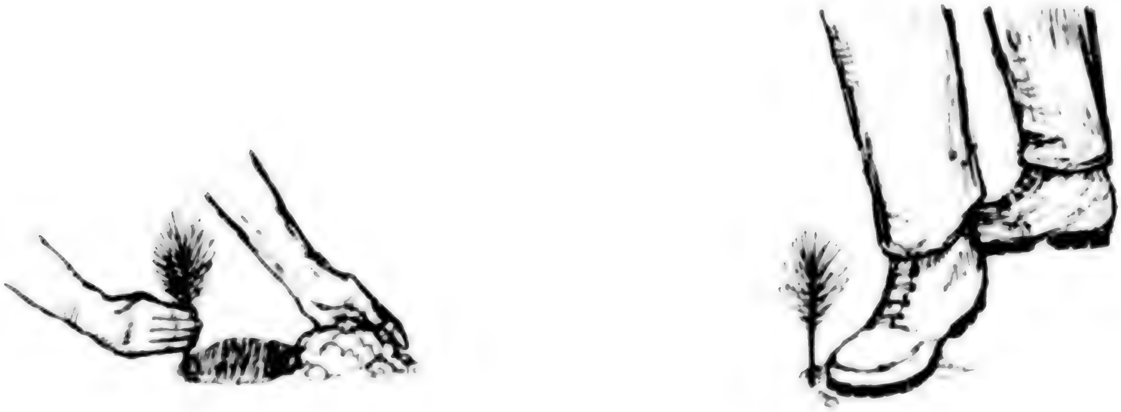
Most trees, shrubs, and vines can be propagated by stem or root cuttings. This type of propagation is used mostly in those areas in which large acreages are being reforested, but the method has value for revegetating surface mined areas in woody species for wildlife habitats (McKnight 1970).

Evergreen cuttings should be made in late summer following the flush of new growth. The success rate of rooting pine cuttings usually is low; therefore, many more cuttings must be made than normal to ensure the desired



Dig a trench with a mattock, then "heel-in" dirt around roots until ready to plant.

A mattock can be used to open holes to plant seedlings or rooted cuttings.



Place seedling at appropriate depth.

Firm soil around seedling and then water thoroughly.

Figure 11. Techniques for "heeling-in" and planting seedlings by hand.

quantity of rooted cuttings. Cuttings should be 4-6 inches long, and the leaves should be carefully cut off the butt end, leaving two to four leaves at the top end.

Cuttings of hardwood deciduous trees should be made in late fall when the trees are dormant. The cuttings should be bundled and buried upside down in sand or placed in moist sand and refrigerated. By spring, callus tissue will have formed on the exposed butt ends of the cuttings. Plant the callused cuttings in a rooting medium consisting of sharp sand and peat moss (3:1). Prior to planting, the cuttings should be treated with a rooting hormone according to label directions. The rooting medium should be about 6 inches deep so that cuttings can be inserted two-thirds of their length. The surface of the rooting medium must be watered thoroughly following the insertion of the cuttings to flush out all air pockets. Keep the cuttings in a greenhouse or covered with glass or plastic. Protect cuttings from direct sunlight and wind, and keep the rooting medium moist. When done properly, propagation by cuttings is an attractive alternative to seedlings since cuttings survive and grow well in comparison to seedlings, and they are less expensive to procure.

Field Plantings

The best time to plant trees, shrubs, and vines is in the early spring as soon as possible following the last major freeze. Balled or containerized plants can be planted into the summer if necessary, but it is best to plant them as early as possible.

The methods employed in the actual planting operation depend on a number of factors such as the kinds of equipment available, the condition of the soil, the accessibility of the planting site for the available equipment, and the species to be planted. On sites that are readily accessible, tractor-drawn tree planters can be used effectively. As a general rule, machine planters can be used on sites having slopes no steeper than 15-20 degrees. Slopes exceeding 20 degrees can often be planted with mechanical tree planters in an up-and-down slope direction. In all cases, care must be taken to ensure that soil material is packed thoroughly around each seedling. It is advisable to have a person follow the machine to tamp soil material around loosely packed seedlings.

On those sites that are unaccessible or unsuitable for machine planting, hand planting is necessary. This is usually done with a mattock (Figure 11) or dibble (planting bar) for making holes for the plants. The hole must be large enough to permit the roots of the plant to spread out fully. It is often necessary to trim off excessively long roots to keep them from doubling up. This is especially important with top-rooted species such as pine and hickories. After planting, tamp the soil material firmly around the plant. The successful establishment of plantings will be greatly enhanced if it is possible to water the newly planted material. When bare-rooted plants are used, provisions for keeping the roots moist must be provided regardless of how inconvenient the operation may be.

The planting patterns to be used will depend upon the specific objective of the revegetation program. Some patterns are, of course, more attractive to wildlife than others. The basic principle to adhere to in revegetating for wildlife is to provide diversity. This can be done in numerous ways including strip and border plantings, clump plantings, plantings along drainage areas or on steep slopes. All of these can be incorporated to some extent in any reclamation project. More specific suggestions pertaining to site-specific revegetation for wildlife are discussed in Section 3 of this guide. Some techniques recommended for the establishment of some select woody species on surface mined lands are illustrated in Table 7.

Maintenance Practices for Woody Plants

The successful establishment of woody plants will require careful attention to several maintenance practices. Some means of watering newly planted bare-rooted stock is essential to achieve a high survival rate. If watering is not feasible, then the planting rate should be increased or repeat plantings made so that enough plants may survive to establish adequate habitat. Small-area plantings or widely-spaced plants may be watered from a truck-mounted water tank. However, the installation of an irrigation system using PVC pipes and appropriate sprinkler heads may prove to be more economically feasible in some situations.

Cattle must be excluded from newly-planted areas. Fencing is, of course, quite expensive, but is necessary to ensure the successful establishment of woody plants. Cattle not only browse on small seedlings, but they also trample them into the ground.

Small woody plants should be protected from other plants that might grow rapidly and smother the seedlings (Vogel 1973). Grasses and legumes may grow so thick and tall thay they interfere with the growth of young tree and shrub seedlings by shading them severely and/or outcompeting them for water and mineral nutrients. Therefore, woody plants should be protected by prohibiting the growth of herbaceous plants near them. This can be accomplished manually or with herbicides. When herbicides are used, care must be taken so that desirable plants are not damaged.

It is important to observe seedlings for insect damage regularly. If an insect infestation is noted, treatment with an appropriate insecticide is usually needed. Management personnel are advised to consult appropriate authorities before using any pesticide.

Table 7. Planting techniques recommended for the establishment of woody species on surface mined lands in Texas and Oklahoma.[a]

Species	Plant Spacing (ft) Within Rows	Plant Spacing (ft) Within Motts	Planting dates
Shrubs			
Amur privet	4-4	6-8	12/1 - 3/1
Autumn olive	4-6	6-8	12/1 - 3/1
Bristly locust	4-4	6-8	12/1 - 3/1
Elderberry	1-4	1-4	12/1 - 3/1
Fragrant sumac	1-4	1-4	12/1 - 3/1
Multiflora rose	1-4	1-4	12/1 - 3/1
Pfitzer juniper	8-10	8-12	12/1 - 3/1
Pyracantha	4-6	6-8	12/1 - 3/1
Russian olive	4-6	6-8	12/1 - 3/1
Wild plum	1-4	1-4	12/1 - 3/1
Yaupon	1-4	5-6	12/1 - 3/1
Vines			
Blackberry, dewberry	1-4	1-4	12/1 - 3/1
Grape	1-4	1-4	12/1 - 3/1
Honeysuckle	4-6	6-8	12/1 - 3/1
Coniferous Trees			
Austrian pine	6-8	10-16	12/1 - 3/1
Eastern red cedar	6-10	10-16	12/1 - 4/1
Loblolly pine	6-10	10-16	12/1 - 4/1
Shortleaf pine	6-10	10-16	12/1 - 3/1
Deciduous Trees			
American elm	8-10	10-15	12/1 - 3/31
Apricot	8-10	10-16	12/1 - 3/31

Table 7. (Concluded)

Species	Plant Spacing (ft)		Planting dates
	Within Rows	Within Motts	
Black locust	8-10	10-16	12/1 - 3/31
Bur oak	8-10	10-16	12/1 - 3/31
Cottonwood	8-10	10-16	12/1 - 3/31
Green ash	8-10	10-16	12/1 - 3/31
Hackberry	8-10	10-16	12/1 - 3/31
Live oak	8-10	10-16	12/1 - 3/31
Mulberry	8-10	10-16	12/1 - 3/31
Osage orange	8-10	10-16	12/1 - 3/31
Red oak	8-10	10-16	12/1 - 3/31
Shumard oak	8-10	10-16	12/1 - 3/31
Sweetgum	8-10	10-16	12/1 - 3/31
Sycamore	8-10	10-16	12/1 - 3/31

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[a] Adapted from U.S. Soil Conservation Service 1976, 1977, 1979b, 1980; Ocean Data Systems, Inc. 1978.

Planting methods for woody species include use of planting bar or mechanical planters. For optimum success, some woody species may require the use of balled or containerized planting stock.

5. COST OF ESTABLISHING WILDLIFE PLANTINGS

To determine the expense of developing wildlife habitat as a land use option, the costs of seeds and plant stock, planting, fencing, and post-planting maintenance must all be considered. Generally, it is not necessary to utilize special land preparation procedures when establishing wildlife plantings. However, woody wildlife plantings are generally established after stabilization with a temporary or permanent cover. It is recommended that the permanent cover consist of rangeland grasses and clovers rather than bermuda grass or other monocultures on wildlife management sites.

It is recognized that the costs of seeds and plant stock vary considerably among suppliers in Texas and Oklahoma and that the cost of labor and techniques utilized in establishing plants depends on availability. However, to illustrate the process of establishing the cost of wildlife plantings, an estimate is made for the wildlife plan discussed in Section 3. In developing cost estimates, information was gathered from the Texas Forest Service on the cost of seedlings; the Oklahoma Conservation Commission (1979) on the cost of fencing, seedbed preparation, fertilizer, and seedlings; and from catalogues of commercial nurseries and seed suppliers on the cost of seeds and seedlings. These cost estimates were based on initial establishment expenses only due to the variability of post-planting maintenance practices. Some maintenance procedures as discussed in Section 4 are highly desirable especially until young plants become established; however, these costs must be calculated on a site-specific basis because of their variability.

FENCING

An essential part of the wildlife management plan shown in Figure 7 is cross fencing to protect the 100 acre management unit from overgrazing by cattle. Cross fencing requires 4,300 ft of five strand barbed wire fence at an estimated cost of $.85/ft. Fencing costs based on 1980 estimates from the SCS total $3,855.

SEEDING

Seeding the 300 acres in Area C to rangeland grasses and clover to establish permanent ground cover costs an estimated $50/acre for the seed mixture of switchgrass, Indiangrass, big and little bluestem, and clover. However, this cost along with the estimated cost of seedbed preparation

($22/acre), seeding operation ($6.00/acre) and soil amendments, fertilizer and lime ($40/acre) are costs that would have been incurred with no additional consideration of wildlife management.

An incremental cost of $4.50/acre would be incurred for seeding a mixture of herbs along with the rangeland grasses and clover on the 100 acre wildlife management unit. If these were mixed with the rangeland grasses and clover mixture, no additional costs would be incurred for the actual seeding operation. The estimated $4.50/acre includes only the cost of seeds at a seeding rate of 1 lb/each for sunflower, sesbania, partridge pea, sericea lespedeza,and common lespedeza.

TREES AND SHRUBS

Establishing fenceline plantings on the wildlife management unit shown in Figure 7 requires planting four rows of trees and shrubs along 4,300 linear ft of fenceline. The plan calls for a row of eastern red cedar, a row of mixed hardwood, a row of Russian/autumn olives, and a row of mixed shrubs such as sumac, plum, and multiflora rose. Rows are spaced approximately 15 ft apart. Utilizing bare-rooted stock available from State and commercial nurseries and a mechanical planter, it should be possible to establish these plantings economically. In this hypothetical situation, planting stock utilized were bare-rooted seedlings planted at the minimum recommended spacing to allow for some mortality during establishment. Table 8 shows the number of plants and their estimated costs to make this fenceline planting.

It is estimated that the fenceline planting illustrated in Figure 7 would require about 6,600 bare-rooted seedlings at a cost of approximately $1300. Cost of planting these seedlings would be approximately $25/acre if planted mechanically, or $40/acre if planted by hand. These costs are based on Texas Forest Service estimates. The fenceline plantings shown in Figure 7 occupy an area of approximately 4 acres. Therefore, the cost of establishing these plantings would range from about $100 to $160.

ADDITIONAL PLANTINGS

The costs of plant stock used to plant the drainageway illustrated in Figure 7 are shown in Table 9. Three 1000 ft rows of trees and shrubs are planted on both sides of the drainageway. Cost of bare-rooted seedlings to make this planting would be approximately $630. Cost of planting these seedlings on the 1.5 acre drainageway plot would be approximately $35 to $60 depending on whether mechanical or hand planting was utilized.

Two loblolly pine strip plantings of approximately five acres each are included in the wildlife management plan illustrated in Figure 7. Establishing these strips would require planting approximately 12,000 trees at the rate of 1200 trees per acre. Loblolly pine seedlings cost approximately $.10 each. Therefore, it would cost $1200 in plant stock plus approximately $25/acre for mechanical planting or $40/acre for hand planting. The total

Table 8. Example of plant stock and estimated costs for fenceline plantings.

Plant	Row	Spacing[a] (ft)	Linear feet	Total plants needed	Cost per[b] plant	Total
Eastern red cedar	1	6	4,300	717	$0.20	$143.40
Black locust	2	8	4,300	134	0.10	13.40
Mulberry	2	8	4,300	134	0.10	13.40
Osage orange	2	8	4,300	134	0.10	13.40
Hackberry	2	8	4,300	134	0.10	13.40
Russian/autumn olive	3	4	4,300	1,075	0.20	215.00
Sumac	4	1	4,300	1,433	0.25	358.25
Wild plum	4	1	4,300	1,433	0.20	286.60
Multiflora rose	4	1	4,300	1,433	0.20	286.60
TOTALS				6,627		$1,343.45

[a] Based on the minimum recommended spacings from Section 4 of this guide.

[b] Based on bare-rooted seedlings.

Table 9. Example of plant stock and estimated costs for drainageway plantings.

Plant	Row	Spacing[a] (ft)	Linear feet	Total plants needed	Cost per[b] plant	Total
Green ash	1	8	2,000[c]	250	$0.10	$25.00
Yaupon	2	1	2,000	1,000	0.30	300.00
Elderberry	2	1	2,000	1,000	0.25	250.00
Cottonwood	3	8	2,000	83	0.10	8.30
Shumard oak	3	8	2,000	83	0.50	41.50
Sweetgum	3	8	2,000	83	0.10	8.30
TOTALS				2,499		$633.10

[a] Based on the minimum recommended spacing from Section 4 of this guide.
[b] Based on bare-rooted seedlings.
[c] A 1000 ft row is planted on both sides of the drainageway.

estimated cost of planting the loblolly pines in the management unit would range from $250 to $400.

A one-half acre wild plum thicket is also included in the wildlife management plan. This thicket can be established by planting ten 250 ft rows of wild plums with a plant spacing of 4 ft and a row spacing of 10 ft. Approximately 600 wild plum bare-rooted seedlings would be required. Wild plum seedlings cost approximately $.20 each. Cost of seedlings would be $120. Planting these seedlings is estimated to cost $25 to $40.

FOOD PLOTS

The establishment of food plots is a re-occuring expense since it must be done on an annual basis. However, the establishment of fenceline, drainageway, and strip plantings and thickets are one-time expenses, if successful. In the management plan illustrated in Figure 7 and discussed in Section 3, approximately 2 acres of food plots are included. Food plots require land preparation (plowing, discing, etc.). It is estimated that this costs $25/acre. Fertilizer costs are approximately $40/acre. Drilling millet and/or a mixture of partridge pea/singletary pea is estimated to cost $10/acre. At a seedling rate of 15-20 lbs/acre, partridge pea and singletary pea are estimated to cost $12/acre and millet, $10/acre. Thus the total annual cost of planting 2 acres of food plot is estimated to be approximately $175.

COST SUMMARY

From the above estimates, it is possible to calculate the incremental cost of establishing wildlife habitat on the site. The approximate costs can be summarized as follows:

Cost of fencing	$ 3,855
Cost of sowing herbs of wildlife value	450
Cost of fenceline plantings	1,460
Cost of drainageway plantings	690
Cost of pine strips	1,600
Cost of plum thicket	160
Cost of food plot	175
Total Incremental Cost	$ 8,390

To establish an improved habitat for wildlife, an incremental cost of $8,390 is estimated above the cost required to reclaim this hypothetical area (Area C) to rangeland. This estimate does not include any post-planting maintenance expenses.

When apportioned over the 300 acre reclaimed rangeland, the implementation of the wildlife plan costs approximately $28/acre or $84/acre for the specific 100 acre wildlife management unit. Thus for $28/acre, it is possible to implement wildlife management practices that should return aesthetic and recreational benefits far in excess of the investment.

Figure 12. Partridge peas in plots provide food for wildlife.

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APPENDIX A. List of State and Federal Agencies in Texas and Oklahoma providing assistance in surface mine reclamation.

APPENDIX A

TEXAS

State Agencies

Fish and Wildlife

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744
(512) 479-4864

Forest and Wildlife Extension Service

Texas Agricultural Extension Service
Texas A&M University
College Station, TX 77843
(713) 845-6411, ext. 40

Forestry

Texas Forest Service
Texas A&M System Building
College Station, TX 77843
(713) 845-2641

Soil and Water Conservation

Texas Soil and Water Conservation Board
1002 First National Building
P.O. Box 658
Temple, TX 76501
(817) 773-2250

Surface Mining Regulatory Authority

Railroad Commission of Texas
Surface Mining and Reclamation Division
P.O. Drawer 12967, Capitol Station
Austin, TX 78711
(512) 475-8751

Water Resources Technology

Water Resources Institute
Texas A&M University
College Station, TX 77843
(713) 845-1851

Federal Agencies

Department of Agriculture

U.S. Forest Service
Region 8, Southern Region
Suite 800
1720 Peachtree Street, N.W.
Atlanta, GA 30309
(404) 881-4177

Soil Conservation Service
101 South Main Street
P.O. Box 648
Temple, TX 76501
(817) 774-1291

Plant Materials Center
Rt. 1, Box 155
Knox City, TX 79529
(817) 658-3922

Regional Biologist
South Technical Service Center
Soil Conservation Service
P.O. Box 6567
Fort Worth, TX 76115
(817) 334-5282

Regional Plant Materials Specialist
Soil Conservation Service, Southern Region
P.O. Box 6567
Fort Worth, TX 76115
(817) 334-5282

APPENDIX A (Continued)

Department of the Army

U.S. Army Corps of Engineers

U.S. Army Engr. District, Ft. Worth
P.O. Box 17300
Ft. Worth, TX 76102
(817) 334-2300

U.S. Army Engr. District, Galveston
P.O. Box 1229
Galveston, TX 77550
(713) 763-1211, ext. 302

Department of the Interior

Office of Surface Mining
Reclamation and Enforcement, Region IV
Scarritt Building
818 Grand Avenue
Kansas City, MO 64106
(816) 374-5109, 2690

Bureau of Land Management
Roswell District Office
P.O. Box 1397
Roswell, NM 88201
(505) 622-7670

Coal Coordinator
U.S. Fish and Wildlife Service
Ecological Services
819 Taylor Street, Room 9A33
Fort Worth, TX 76102
(817) 334-2961

Water and Power Resources Service
Southwest Region
714 S. Tyler St., Suite 201
Commerce Building
Amarillo, TX 79101
(806) 376-2164

U.S. Bureau of Mines
Department of the Interior
Washington, DC 20241
(202) 634-1004

OKLAHOMA

State Agencies

Fish and Wildlife

Oklahoma Department of Wildlife Conservation
1801 N. Lincoln
P.O. Box 53465
Oklahoma City, OK 73105
(405) 521-3851

Forestry

Oklahoma Forestry Division
State Department of Agriculture
State Capitol, Room 122
Oklahoma City, OK 73105
(405) 521-3886

Forestry and Wildlife Extension Service

Oklahoma Agricultural Extension Service
Oklahoma State University
Stillwater, OK 74074
(405) 624-5398

Heritage and Conservation Service
(Endangered Species Information)

Oklahoma Natural Heritage Program
770 Van Vleet Oval
Norman, OK 73109
(405) 325-2791

Soil and Water Conservation and Abandoned Mine Reclamation

Oklahoma Conservation Commission
114 State Capitol Building
Oklahoma City, OK 73105
(405) 521-2384

Surface Mining Regulatory Authority

Oklahoma Department of Mines
4040 N. Lincoln Blvd., Suite 107
Oklahoma City, OK 73105
(405) 521-3859

Water Resources Technology

Oklahoma Water Resources Research Institute
Oklahoma State University
203 Whitehurst Hall
Stillwater, OK 74074
(405) 624-6368

Federal Agencies

Department of Agriculture

U.S. Forest Service
Region 8, Southern Region
Suite 800
1720 Peachtree Street, N.W.
Atlanta, GA 30309
(404) 881-4177

Soil Conservation Service
Agricultural Center Office Building
Farm Road and Brumley Street
Stillwater, OK 74074
(405) 624-4437

Regional Biologist
South Technical Service Center
Soil Conservation Service
P.O. Box 6567
Fort Worth, TX 76115
(817) 334-5282

Regional Plant Materials Specialist
Soil Conservation Service, Southern Region
P.O. Box 6567
Fort Worth, TX 76115
(817) 334-5282

Department of the Army

U.S. Army Corps of Engineers

U.S. Army Engr. District, Tulsa
P.O. Box 61
Tulsa, OK 74102
(918) 581-7311

APPENDIX A (Concluded)

Department of the Interior

Office of Surface Mining
Reclamation and Enforcement, Region IV
Scarritt Building
818 Grand Avenue
Kansas City, MO 64106
(816) 374-5109, 2690

Bureau of Land Management
Oklahoma Area Office
200 N. W. 5th Street, Room 548
Oklahoma City, OK 73102
(405) 231-4481

Coal Coordinator
U.S. Fish and Wildlife Service
Ecological Services
222 S. Houston, Suite A
Tulsa, OK 74127
(918) 581-7458

Water and Power Resources Service
Southwest Region
714 S. Tyler Street, Suite 201
Commerce Building
Amarillo, TX 79101
(806) 376-2164

U.S. Bureau of Mines
Department of Interior
Washington, DC 20241
(202) 634-1004

APPENDIX B. Ecological information and management practices for selected game and nongame wildlife associated with reclaimed lands in Texas and Oklahoma.[2]

- White-tailed deer
- Bobwhite quail
- Mourning dove
- Cottontail rabbit
- Waterfowl
- Furbearing animals
- Nongame birds

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[2] The information in this appendix was adapted predominantly from U.S. Forest Service (1969,1971), Rafaill and Vogel (1978), U.S. Soil Conservation Service (1979a,b), and Hinkle *et al*. (1980). All figures (photographs) in this appendix are provided courtesy of Texas Parks and Wildlife Department.

Appendix B.

WHITE-TAILED DEER (*Odocoileus virginianus*)

The white-tail deer will inhabit a number of forest and non-forest situations. A revegetation plan which eventually provides a distribution of cropland, grassland, and young woodland will promote deer, although most any reclamation plan will attract deer from surrounding areas even in the first few years after reclamation. White-tailed deer are the most abundant big game animal in Texas and Oklahoma.

Habitat Needs

Food. Plants eaten by deer can be divided into three general categories: (1) browse or woody plants, (2) forbs or weeds (herbaceous broadleafed plants), and (3) grasses. The percentage these three types of food comprise in the diet of deer varies between seasons, vegetational areas, soils, individuals, and competition. Deer are very selective if they have a choice of foods and select foods because of their palatability, succulence, availability, and nutritional value. A good deer diet consists of 3 to 7 lbs of dry matter per day and contains from 14 to 18 percent protein. Browse will make up a portion of the diet during all seasons, but normally increases during winter. Forbs, grasses, seeds, and fruits are important food items during the spring, summer, and early fall. In addition to native plants, deer also like many agricultural crops such as peanuts, corn, vetch, peas, oats, ryegrass, wheat, and others.

Cover. Where deer are found, there is some type of woody cover. Cover may take many forms such as trees and brush in draws and along slopes; rough topography; or large, solid tracts of timber and brush. It may be motts or thickets in open areas, or along streams in prairie areas. Whatever form the plants take must be adequate to provide cover from weather, predators, man, and usually furnish food.

A mixed cover type with numerous species is much more desirable than one containing only one species. Good woodland cover would contain a mixed forest stand with lots of mature hardwoods and available hardwood shrubs. The ideal percentages of cover would vary from 10 to 50 percent of an area and would depend on the brush species, deer densities, and hunting pressures. Fawns are frequently hidden in areas of tall grass.

Water. Deer need free water for drinking, and needs are greatest during hot weather. Daily consumption varies from one-half to 1 gal. Water should be distributed over an area. In dry portions of Texas and Oklahoma, water may limit population density.

Space. The area needed to maintain a deer herd will be tied to the relationship of food, cover, and water. How these elements are dispersed over an area, along with predation and man's influence, will determine the

Figure 13. White-tailed deer will inhabit reclaimed surface mined lands provided adequate browse is available.

minimum size of an area necessary to support a herd. Normally at least several hundred acres of good quality habitat containing food, cover, and water are required. Deer have a home range which is the area where an individual animal spends all or most of its time. It contains all the food, shelter, water, cover, and other needs of the individual. The home range size varies but is normally less than 640 acres. Deer may feed in seasonal patches, but return to their home range. A buck in rut may leave his home range, but will return when it is over.

Management Practices

--Management of deer habitat primarily involves creating, then retaining, adequate and appropriate food, cover, and water. Deer need a diverse forage supply because they cannot exist on a diet of grass alone.

--Include in the revegetation plan a variety of vegetation types including hardwoods, conifers, and shrubs, in addition to herbaceous species.

--The healthiest deer herds are those found on ranges supplying the greatest variety and abundance of woody and succulent green plants of high nutritive quality throughout all seasons of the year.

--Food needs can be met by including fruit-producing species, grasses, forbs, and mast and browse plants. Some of the choice native species of foods are rattan, trumpet creeper, jessamine, greenbriar, honeysuckle, fringetree, beautyberry, gallberry, possumhaw, yaupon, rusty blackhaw, red bays, white bay, sumac, blackberries, dewberries, blueberries, sweetleaf, hawthorn, persimmon, beech, oaks, maples, blackgum, sassafras, and mushrooms. Favored agricultural crops are clover, corn, soybeans, oats, wheat, rye, ryegrass, cowpeas, and others.

--Oaks should be favored in the management planting scheme, since acorns provide a highly nutritious and favored food source.

--In pure pine management, understory trees such as dogwood, yaupon, beautyberry, sweetleaf, and rusty blackhaw should be spared and encouraged. These provide good food, while not interfering with pine growth.

--Cover needs require woodlands nearby with woody thickets, conifers, and tall weeds for escape.

--Sufficient brush cover should be maintained along water courses which usually serve as travel lanes. Strips of brush should be wide enough to prevent seeing through them at most points from December through February, when most plants have lost their leaves.

- --When tree growth reaches beyond the sapling stage, thinning and trimming is necessary to promote new sprout growth and browse plants for food. For hardwoods, low thinnings are more productive of sprout growth in young stands. In older stands, crown thinnings stimulate greater seedling growth and production of mast. For conifers, in young and old stands, crown thinnings are preferred.

- --In South Texas, alternate strips of cleared areas and brush produce good deer habitat, although clearing in an irregular pattern is more desirable. Where cleared areas tend to be excessively large, islands of brush should be left within the cleared areas to provide escape cover.

- --Young pine plantations are used extensively as bedding areas, if other heavy cover is absent.

- --At least a quarter acre of dense cover should be available in every 60 acres.

- --When large cleared areas exist, a belt or block of brush should be left every 200 to 300 yd to break up the open spaces and provide covered travel lanes connecting these strips.

- --Long rectangular openings (from 2-10 acres each) as food plots provide nourishment for deer in the winter. These areas should be planted to clovers (crimson, ladino, button, burr, and red), vetch, alfalfa, fescue, rescue grass, oats, ryegrass, rye, winter wheat, shrub lespedeza, or soybeans.

- --Since deer and livestock overlap to some degree in their food requirements, the presence of livestock will generally depress deer populations. In terms of competition, goats are the chief competitors, followed by sheep, and then cattle. Livestock grazing and the resulting competition for food should be minimized. This can be done by deferring areas important to deer during critical periods, properly stocking a unit, and implementing grazing systems.

- --A source of open water should be available near cover. Water sources should be located within 1 mi of each other.

- --Barbed wire fences kill many deer either by scratches which become infected, or by entrapment in the two top wires. Harm can be prevented by having smooth wire for the two top strands and spacing these strands more than 12 inches apart.

--Where deer are uncommon, transporting stock from one locality to another where suitable habitat has been provided has proved successful. The "nucleus" stock should be protected for several seasons before hunting.

--Deer populations should be managed not to exceed the carrying capacity of the site. Buck-doe ratios of 1:3 to 1:5 will offer good potential for quality and quantity management objectives. A harvest quota is recommended annually for both bucks and does. Approximately 35 percent of the standing buck crop should be harvested. Once stabilized, the doe population should be harvested with a quota equal to the number of young does produced.

--Rangelands should be seeded with forbs and grasses used by deer.

--In improved pasturelands and croplands, species that have value for deer can be included. Established pastures can be overseeded with legumes or cool season annuals. Existing woody cover areas in pasturelands along fence rows and bottoms can be retained and fenced to provide deer (choice) browse species.

--Hunting should be employed as a management tool.

BOBWHITE QUAIL (*Colinus virginianus*)

Bobwhite quail are one of the most popular game species in Texas and Oklahoma. Reclaimed mine lands have great potential to be managed for bobwhite quail. Quail thrive in an area providing a good interspersion of open woodlands, brush, grass, and cultivated lands.

Habitat Needs

Food. Quail food consists of about 15 percent animal matter and 85 percent plant matter. The animal food is predominantly insects such as beetles, weevils, caterpillars, and crickets. Young birds feed almost exclusively on the animal matter. The plant matter is composed mainly of seeds and fruits although some green vegetation is taken. Plants which reproduce a smooth, hard seed such as ragweed, goatweed, and partridge pea are important food plants. Agricultural crops such as corn, grain sorghum, legumes, soybeans, and small grains are utilized. High protein green forage is important during winter periods.

Cover. Quail are edge animals and inhabit idle fields, open woodland, crop fields with weedy edges, pastures, and rangeland. Nesting, loafing, escape, and protective cover near dusting and feeding areas is necessary in the establishment of quail habitat. Loafing or resting cover is used during

Figure 14. Bobwhite quail seeking shelter in native grasses.

the middle of the day between feeding periods. Low growing woody plants provide loafing cover and should not be over 200 to 300 ft apart. The previous year's growth of herbaceous cover provides ideal nesting sites. Location of the nest is often near the edge of rough grass. This permits the chicks, when they hatch, to be led to thinner cover for feedings. As a result, the edge of roads, fence rows, or firelanes are favorite spots selected for nesting.

Shrub thickets provide escape cover and are needed on about every 15 acres. These thickets should be one-fourth to 10 acres in size. Roosting cover must provide warmth at the ground level and not restrict flight in any direction. Quail roost in a circle with their heads looking outward and their tails toward the center.

Water. Water requirements are generally met from the food consumed, dew, or surface water.

Space. The home range of a covey is normally about a quarter mile and rarely exceeds a square mile. Generally, the closer together the necessary types of cover and food are, the smaller the annual range will be. The maximum carrying capacity for quail is about one bird per acre, which is rarely attained.

Management Practices

--Successful management for quail depends on the development of a diversified cover, ideally containing cropland, grassland, brushland, and woodland in equal amounts.

--Where the postmining land use is cropland, "cover lanes" or strips of different plantings that run through a large continuous field can be developed. These strips need not sacrifice a large amount of agricultural land or interfere with the agricultural program.

--Eroding gullies planted to soil-holding plants like black locust, wild plum, and sumac provide excellent permanent cover. In other locations, cover requirements can be satisfied by maintaining brush areas such as honeysuckle patches, greenbriar and blackberry thickets, patches of sericea or kobe lespedeza, unmowed patches of grasses and annual weeds, and hedgerows.

--Grazing should be restricted where maximum productivity of quail is desired.

--Food plots near cover and within the strip plantings in grainfields are useful in maintaining populations over the winter. Suitable plants are corn, wheat, rye, oats, buckwheat, soybeans, millets, milo, maize, and clover.

--One planting of a quarter to one-half acre of food per 20-25 acres is usually adequate for one covey of bobwhite quail.

--Select seed or plants to meet local soil conditions. A good mixture for a half acre plot would include:

A. Millet (10 lb seed)

B. Vetch, 3 lb each planting (6 lb)

C. Shrub lespedeza (700-800 plants)

D. Pfitzer juniper, pyracantha, autumn olive, or yaupon (4 to 5 plants)

E. Annual lespedeza (8 lb)
or
Corn (6 lb)
or
Cowpeas (one-fourth bu).

--One side of the planting should be adjacent to woods or wildlife cover (e.g., hedgerow, field border, etc.)

--Rotate A and E every other year. Plant on contour or sloping land.

--Discing encourages growth of sunflowers, goatweed, pigweed, sticktights, ragweed, croton, partridge pea, and other forbs. When fertilized, these plants grow vigorously and produce more seeds.

-- Maintaining woody fence rows and hedgerow plantings will provide escape cover for quail along field edges.

--In pine stands managed for timber, a high quail population can be maintained by (1) control burning every three years, sparing some dense cover by fire lanes, (2) discing and fertilizing strips through the woods, and (3) establishing plants wherever openings are available.

MOURNING DOVE (*Zenaida macroura*)

Mourning doves prefer open or semi-open lands and can be attracted to revegetated mined areas by providing food plots and water to utilize during their migration. They are a popular game species in Texas and Oklahoma.

Habitat Needs

Food. Seeds from native grasses, cultivated grains, and forbs such as croton and sunflower are the major food items. Insects are a minor item in the diet. Gravel or grit is always present. The most popular feeding areas are fields where a crop has been harvested, leaving waste grain. A condensed list of food consists of the following percentages:

	Spring	Summer	Fall	Winter
Grains	20-50%	10-31%	5-15%	10-25%
Legumes	0-15	5-15	10-30	5-15
Grasses and sedges	5-15	30-50	20-40	30-60
Trees and shrubs	0-5	0	0-10	0-15
Spurges	0-5	5-20	0-10	0-5
Composites, weeds, and herbs	20-50	5-25	15-25	5-15

Cover. The mourning dove is one of the most adaptable of all species as indicated by its wide range. However, they do not generally inhabit forests, plains, vast open fields, marshes, or prairies. The broken topography of trees and openings brought about by agriculture seem to be more desirable. Trees, hedgerows, shrubs, and wires between utility poles furnish doves with nesting and roosting sites. Doves prefer to feed on ground where the vegetation is sparse rather than on dense perennial grasses.

Water. The need for water is high especially during the nesting season; otherwise, it is very seldom a limiting factor due to the bird's mobility.

Space. Space is not a limiting factor except during the nesting season.

Management Practices

--Increased weed production through discing areas of perennial grasses provides additional food.

Figure 15. A mourning dove raising young.

--Leaving grain crop residues and weed seeds lying on top of the ground supplies doves with food.

--Doves will be attracted to any open or semi-open area which has a harvestable grain crop. Since they do not scratch for food, the ground should be free of heavy, grassy cover.

--Doves use of corn and grain sorghum fields can be increased greatly by harvesting at the earliest possible date. Cutting these crops for silage, during late August, will guarantee heavy use of the fields by doves.

--Heavy seeded annual grasses such as millet are preferred plantings. Perennial cover species, producing late spring summer seedlings, provide seed during the fall migration period.

--A brushy woods edge or clumps of conifers or shrubs provide roosting and nesting sites. Planting trees,singly or in groups, on sites lacking timber will be attractive to the birds.

--Doves require water at least twice a day. Any open water source is usable if the bank is not too steep and if free of brushy and heavy grass cover.

--Continual hunting will drive away birds. Do not shoot a small field more than one day a week. Half-day hunting is preferable in heavily hunted areas.

--Planting rangeland with hard seed producing grasses such as Kleingrass, switchgrass, bristlegrass, sorghum almum, and blue panicum improves dove habitat.

COTTONTAIL RABBITS (*Syvilagus floridanus*)

Cottontail rabbits will rapidly inhabit reclaimed mine lands in Texas and Oklahoma where pastureland, cropland, and woodland or combinations of these are interspersed with brushy areas. Rabbits rank second in Texas in terms of hunting pressure and offer a challenge to the most skilled hunter. However, in Texas cottontails are not legally recognized as game species.

Habitat Requirements

Food. Cottontails eat a wide variety of plants and plant parts, both herbaceous and woody. The availability of woody species is essential during winter months when herbaceous plants are not as available due to dormancy and snow cover. Food sources should be adjacent to low, relatively dense ground cover or brushy cover.

Cover. Nesting cover is usually in dense low vegetation such as the grasses, grass/forb mixtures, vines, shrubs, or combinations of these. Escape cover on reclaimed land can consist of dense vegetation, accumulations of brush, or openings and crevices among rocks. Hollow fallen logs can provide cover in the adjacent forest or woodland.

Water. Water in the free state is not essential to the cottontail's existence. Water requirements can be met by moisture from succulent plants and dew.

Range. The home range of a cottontail is seldom more than 20 acres; therefore, emphasis must be placed on the close proximity of food and cover areas.

Management Practices

- Cottontail rabbits benefit from the management practices used to encourage bobwhite quail populations, except that more emphasis must be placed on year-round production of succulent green forbs.

Figure 16. Cottontail rabbit utilizing herbaceous habitat.

WATERFOWL (Family *Anatidae*)

During the reclamation of surface mined lands in Texas and Oklahoma, it is frequently possible to construct ponds and small lakes providing habitat for waterfowl. Two types of ducks are commonly found in Texas and Oklahoma--surface feeding ducks and diving ducks. Surface feeding ducks, sometimes called "puddle ducks" or "dabblers", represent the subfamily *Anatinae*. Species commonly found in this group include mallard, black, pintail, gadwall, blue-winged teal, green-winged teal, cinnamon teal, American widgeon, shoveller, and wood duck. Collectively, this group can be distinguished from a second group called "diving ducks" by differences in both appearance and habitat.

The subfamily *Anthyinae* is generally referred to as "divers." Included in this group are the canvasback, redhead, ring-necked, lesser scaup, greater scaup, and bufflehead.

Geese of the subfamily *Anserinae* frequently stop off in Texas and Oklahoma on their migration. This subfamily includes the Canada, white-fronted, snow, brant, and Ross' species.

Habitat Needs

Food. Waterfowl utilize a wide variety of food types consisting mainly of vegetable matter in the form of seeds, leaves, stems, and roots of aquatic plants in addition to various amounts of animal matter. Overlapping of food types is not uncommon in certain locales where habitat is suitable for both groups of ducks--divers and surface feeders. In Texas, is has been determined there are basically three plant groups important to ducks. These three groups include plants commonly referred to as smartweeds, millets, and pondweeds. Statewide, over 30 species of smartweed, at least a half dozen millets, and over a dozen species of pondweed are of known importance to ducks. In addition, particularly among surface ducks, a tremendous amount of domestic grain is utilized annually.

Diving ducks utilize a variety of food types including seeds, stems, leaves, and roots of aquatic plants. Their diving abilities enable them to better utilize many submergent vegetative types to depths of 6 ft. Research data based on stomach analysis reflect the use of such vegetation although a wide variety of food types are commonly utilized by both divers and surface feeders. The following is a list of food plants preferred by divers as taken from various research materials:

Widgeongrass
Pondweed
Waterlily
Smartweed
Watershield
Coontail
Duckweed
Spike rush
Bulrush
Algae
Musk grass
Wild celery

Figure 17. Waterfowl may benefit from pond construction.

Each of these plants is representative of one or more species. Plant preference depends on the species of duck and varies from region-to-region, and within a given region, from locale-to-locale. It is not uncommon to witness both diving and surface ducks feeding side by side. However, divers do exhibit a food preference unique to this group alone, and likewise habitat requirements for divers vary accordingly.

Geese feed almost exclusively on vegetative matter, especially agricultural grain crops such as sorghum, corn, and rice. Some animal matter such as insects, crustaceans, and mollusks are occassionally utilized when geese feed in the aquatic environment.

Cover. The term "cover," as it applies to other wildlife species, is not a necessity with waterfowl. Generally, waterfowl prefer more open conditions relying on eyesight and speed of flight to escape predation. However, the presence of loafing or resting areas, included here as cover, have been found to be a useful, if not important, element of waterfowl habitat. Such areas provide a place for both resting and preening. Waterfowl do, on occasion, utilize certain types of vegetative cover as shelter in the presence of severe weather and/or high winds. Shoreline areas affording protective cover along bays, coves, inlets, backwater areas, and stilling basins are but a few examples. One species which relies heavily on woody cover is the wood duck. Wood ducks require cover for breeding, rearing, young, and roosting.

Diving ducks, as with other waterfowl, are not cover-dependent, although areas for resting are considered an important element in habitat development. The importance of loafing or resting areas is generally overlooked. Small islands, sand bars, knolls, open margins, or exposed mud flats provide valuable areas for loafing, preening, sunning, sleeping, and on occasion protection from predators. During adverse weather conditions, divers will seek protective cover from high winds and rough water; however, observation indicates the diver's fondness for open water, even more so than those ducks in the surface feeding group.

Water. Water may be considered the basis for all existing waterfowl habitat and the principal element in the development of habitat for waterfowl.

Surface feeding ducks and geese generally prefer more shallow water areas ranging in depth from 6 to 18 inches. These waters support the forage resource preferred by surface feeders and are also better suited to the foraging capabilities of this group.

Diving ducks are inhabitants of open, deep water habitats such as those found within rivers, reservoirs, and large ponds. Likewise, food preference is linked to vegetative types commonly associated with such areas.

Construction of earthen structures suitable for the development of deep water habitat for divers is more often the result of an objective other than principally waterfowl management. Irrigation reservoirs, ponds, floodwater retarding structures, canals, and small lakes provide a suitable water medium. Water quality and water management are essential to the development of food plants for divers just as with all waterfowl.

Management Practices

--Waterfowl can be considered where the option to leave the sediment pond or create an impoundment exists.

--Fencing should be utilized to keep grazing animals from trampling the shoreline and food plantings.

--Smartweed, wild millet, and bulrushes should be planted only on the periphery of impoundments or in the zone of water-level fluctuations.

--Important food plantings include wild rice and wild millet, propagated by seed; and smartweed, propagated by tuber planting.

--Upland or low-lying level fields can be used to attract waterfowl if the soil type is one that will hold water. A low dike, 2 to 3 ft high, must be thrown up to retain the water. Subsequent seeding with corn or browntop millet, with a little milo or cattail millet, will provide both food and cover. Ducks and geese will also utilize green forage such as clovers if planted nearby or within the berm.

--Ponds or marshy areas near forestland are attractive to mallards and wood ducks. Ponds should be planted to corn and browntop or Japanese millet and flooded by mid-October or early November and drained by March.

--In areas where inadequate sites (tree cavities) prohibit wood ducks from producing young, nest boxes can be constructed. Plans for construction can be obtained from State or Federal fish and wildlife agencies. Measures must also be taken to provide brood-rearing habitat for wood ducks if inadequate cover exists.

--Open water areas should be at least a quarter acre in size to attract migrant waterfowl. In general, the larger the impoundment, the better the opportunity for attracting waterfowl. Small areas, less than 3 acres, will not receive much use, unless they are fairly close (less than 5 miles) to a large concentration of waterfowl.

--Shooting pressure is very important. Hunting should initially be restricted to only two or three times per week or half-days only.

--In areas which are heavily hunted, draw-down of the water level should be started at the close of the duck season. Spent lead pellets are actively consumed by ducks that mistake them for gravel. Lead poisoning may then result. If death does not occur, the bird is nevertheless weakened, increasing its vulnerability to predators, diseases, and parasites. Overfilling of potential feeding areas to depths exceeding 24 inches is also effective providing no geese or diving ducks are present. Another option to reduce potential lead poisoning would be to impose a steel-shot only regulation.

--Ponds and lakes should be constructed to have large shallow areas where water depths do not exceed 18 inches. Surface feeding ducks seldom feed at greater depths.

--Where feasible, habitat may be improved througn vegetative propagation by plantings using commercially available plant materials or, where possible, from materials collected locally.

--Careful control of water clarity through erosion prevention is essential for the establishment and maintenance of submerged vegetation.

--Land with moderate-to-light woody overstory of oak, hickory, ash, and other desirable mast-producing trees may be managed for waterfowl. On suitable soils, levees may be constructed to provide for water impoundment during the waterfowl season. Such areas are attractive to ducks, such as the mallard and wood duck, and are notably productive in areas where such developments are feasible. Hardwoods may be impounded during winter months without harm provided the area is drained prior to the onset of spring and new season growth. For this reason, care must be taken to provide adequate drainage to remove water within the impoundment or possibly water from surface runoff outside levee borders. Open areas may be planted to annuals as an additional food source.

--Stocktanks have a poor reputation as quality waterfowl habitat although many are utilized each season as stopover or resting areas during migration periods. Ponds with an appreciable shallow water area may be managed by draw-down and/or planting, provided some means of water control is available, either by drainpipes or by pumping. However, the recharge rate of ponds is often too rapid to allow time for suitable plant establishment or too slow to recover within a reasonable time period.

FURBEARING ANIMALS

Red and gray fox, raccoon, opossum, skunk, mink, coyote, and bobcat are all important furbearing species that can utilize or inhabit reclaimed surface mines. It is normally not practical nor necessary to plan, develop or manage specific habitat for them.

Habitat Requirements

Food. Furbearing animals generally eat both plant and animal foods, and availability of desired foods is a major factor in their management. Important animal food items include mice, rabbits, frogs, birds, bird eggs, a variety of large insects, and insect larvae. Furbearers also utilize plant material, especially fleshy fruits, such as wild plums, grapes, and persimmons. Raccoons normally live and feed along water courses and swamps in forested areas, but they will seek food on reclaimed surface mines especially where water is present or nearby.

Cover. Raccoons are found primarily in bottomland hardwood forests and marshes, but will use a variety of other habitats including cultivated areas, tall weeds, broomsedge, pine-hardwoods, and pine. Ground and tree dens are used for shelter and escape although tree dens are preferred for raising young. Rock outcrops and brush piles can also provide denning cover. Red and gray foxes and skunks use a diversity of cover types. The skunks prefer weedy and brushy fields in semi-open country near water, and the foxes and coyotes use similar areas and woodlots. Opossum tend to favor wooded areas along streams, lakes, or swamps. Mink inhabit areas near streams, marshes, lakeshores, and riverbanks. They prefer dense vegetation and small streams with pools that have irregular shorelines. Foxes, skunks, and opossum utilize ground dens.

Water. All of the furbearers require a source of free water daily. However, because they either live near water or tend to travel widely during their search for food, finding water usually does not present a problem.

Figure 18. Optimum habitat for raccoons includes shallow water areas.

Space. The home range of furbearers is generally large; therefore, the use of a newly revegetated surface mine by these animals would be due mostly to local animals attracted to it from within a radius of about 1 mi. For example, raccoon will range up to 2 mi/day along shores. Their home range is about 300 acres. Gray foxes, coyotes, and bobcats have home ranges of several thousand acres.

Management Practices

--Revegetation schemes that promote the increase of rodents, rabbits, ground-nesting birds, and insects increase the resident population of predatory furbearers.

--Planting of trees and shrubs which produce fleshy fruits provides food sources for many of the furbearing animals.

--Providing dense cover by planting or preserving greenbriars, honeysuckle thickets, dense hedgerows of multiflora rose, bristly locust, and yaupon increases furbearing animal populations.

--Building stock tanks and preserving marshy areas provides habitat and food for these species.

--Controlling feral dogs protects furbearing animals.

--Providing den sites (hollow logs, concrete pipes, rock piles, brush piles, etc.) increases the population of furbearing animals immediately following reclamation.

NONGAME BIRDS

Any revegetation effort on a surface mined area will attract some species of nongame birds. Revegetation which provides a wide diversity of habitat types will support a diversity of nongame birds. Texas and Oklahoma have many different kinds of songbirds, birds of prey, and migratory species.

Habitat Requirements

Food. Nongame birds vary considerably in their food requirements. Generally, the seed and fruit-eating species and insect-eating species will benefit from the management practices suggested for quail and dove. Predatory birds like owls and hawks feed primarily on rodents.

Water. Many of the nongame birds get water to meet their metabolic needs from the food they eat. However, stockponds and/or streams are essential for some species. Wading birds, kingfishers, and nongame species of ducks, and grebes require water as part of their habitat.

Space. Many of the nongame birds are migratory (e.g., hawks, shorebirds, hummingbirds, robins, etc.). Others spend their entire lifecycles in a relatively small area. Space is not usually the limiting factor to a site's ability to support a diversity of nongame birds.

Management Practices

--Concentrate management on the more moist and fertile sites because these locations are usually the center of activity for birds in the area.

--Maintain a variety among the planted species. Include species that form thickets (i.e., most shrubs, nearly all vines) and bear nuts or fleshy fruits. Also include mixtures of evergreen and deciduous trees.

--Good nongame food plots can be planted in corn, buckwheat, sunflowers, and Japanese or German millets.

--Hedgerows and woodland border plantings should be encouraged. Autumn olive, dogwood, tatarian honeysuckle, and cherry are high food value plants for this purpose.

--Leave dead or dying trees on non-mined areas standing, unless they are hazardous. These provide nesting locations for woodpeckers, owls, and other species; the trees also maintain insect populations upon which birds feed.

--Maintain a moderate to dense understory and break up single-aged stands that have sparse understories. This may be accomplished on adjacent non-impacted lands to mitigate mining impacts.

--Mix or intersperse the growth stages of trees within a reclaimed forest. Many bird species actively use the edges between different stages.

--Mix the habitat components on a smaller scale than would be used for managing game animals. During the breeding season, many species of birds will stay within one-half acre of land.

--A long term maintenance program to mitigate impacts for nongame birds could include the following general procedures on adjacent forested lands:

(1) Cut selected trees throughout the area annually, trying to maintain the maximum diversity and variety of overstory and understory.

Appendix B. (Concluded)

(2) Leave several mature and dead trees standing.

(3) Maintain an overstory canopy closure of from 50 to 75 percent.

(4) Use more crown thinning than low cutting to open the canopy.

(5) Cut in the fall or winter to cause the least disturbance to birds.

(6) Keep livestock out, except in a limited amount where understory is undesirably thick.

APPENDIX C. Vegetation recommended for surface mine reclamation for wildlife in the Texas-Oklahoma area.

Appendix C. Vegetation recommended for surface mine reclamation for wildlife in the Texas-Oklahoma area.

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Coniferous Trees			
Eastern red cedar *Juniperus virginiana* (L.)	1, 2, 3	23, 37, 47, 54	F-1, C-1
Shortleaf pine *Pinus echinata* (Mill)	1, 2	23, 37	F-1, C-1
Loblolly pine *Pinus taeda* (L.)	1, 2	23, 37, 43, 56	F-1, C-1
Slash pine *Pinus elliottii* (Engelm.)	1, 2	12, 14, 23, 32, 37, 51	F-1, C-1
Virginia pine *Pinus virginiana* (Mill)	1	23, 56	F-1, C-1
Chinese arborvitae *Thuja arborvitae* (L.)	2	23, 37	F-2, C-1
Hardwood Trees			
Boxelder *Acer negundo* (L.)	1, 2, 3	54, 55, 56	F-3, C-2
Red maple *Acer rubrum* (L.)	1	5, 25, 36, 42, 51, 52, 53, 55	F-3, C-3
Silver maple *Acer saccharinum* (L.)	1	5, 12, 14, 25, 33, 36, 37, 39, 42, 51, 52, 53, 55, 56	F-3, C-2
River birch *Betula nigra* (L.)	1	12, 25, 33, 36, 39, 41, 42, 51, 52, 53, 55	F-3, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Pecan *Carya illinoensis*(Wang) K.Koch	1, 2, 3	25, 28, 36, 52, 53, 55, 56	F-1, C-2
Hickory *Carya* spp.	1, 2, 3	55	F-1, C-2
Sugarberry *Celtis laevigata* (Willd.)	1, 2, 3	52	F-1, C-2
Hackberry *Celtis occidentalis* (L.)	1, 2, 3	36, 37, 41, 52, 53, 54	F-1, C-2
Redbud *Cercis canadensis* (L.)	1, 2	2, 5, 12, 14, 22, 24, 25, 28, 33, 36, 37, 39, 41, 42, 52, 53, 54, 55	F-2, C-2
Persimmon *Diospyros virginiana* (L.)	1, 2	24, 25, 28, 51, 52, 53, 55	F-1, C-2
American beech *Fagus grandifolia* (Ehrh.)	1, 2	52, 56	F-2, C-2
Green ash *Fraxinus pennsylvanica*(Marsh)	1, 2, 3	2, 5, 23, 25, 36, 37, 39, 41, 42, 51, 52, 53, 54, 55	F-2, C-2
Honey locust *Gleditsia triacanthos* (L.)	1, 2, 3	2, 5, 12, 23, 37, 41, 52, 53, 54, 55	F-2, C-2
Black walnut *Juglans nigra* (L.)	1, 2	22, 23, 25, 36, 37, 42, 54, 55, 56	F-1, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Sweetgum *Liquidambar styraciflua* (L.)	1, 2	5, 12, 14, 23, 25, 36, 39, 41, 42, 51, 52, 53, 55, 56	F-2, C-2
Yellow poplar, tulip tree *Liriodendron tulipifera* (L.)	1, 2	12, 33, 36, 39, 42, 53, 55, 56	F-2, C-2
Osage-orange, Bois d'Arc, horseapple *Maclura pomifera* (Raf.) Schneid.	1, 2	23, 37, 54, 56	F-3, C-1
Red mulberry *Morus rubra* (L.)	1, 2, 3	23, 37, 57	F-1, C-2
Sycamore *Platanus occidentalis* (L.)	1, 2, 3	2, 5, 12, 14, 25, 33, 36, 39, 41, 42, 51, 52, 53, 54, 55, 56	F-3, C-2
Cottonwood *Populus deltoides* (Marsh.)	1, 2, 3	23, 37, 54	F-3, C-2
Apricot *Prunus armeniaca* (L.)	1, 2, 3	25, 28, 36, 53, 55	F-1, C-1
Black cherry *Prunus serotina* (Ehrh.)	1, 2, 3	24, 36, 52, 54, 55, 56	F-1, C-1
Crabapple *Pyrus ioensis* (Wood) Bailey.	1, 2, 3	12, 14, 24, 25, 35, 39, 55	F-1, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Southern red oak *Quercus falcata* (Michx.)	1, 2	14, 37, 42, 51, 55	F-1, C-1
Bur oak *Quercus macrocarpa* (Michx.)	1, 2, 3	22, 24, 37, 53, 54, 56	F-1, C-1
Blackjack oak *Quercus marilandica* (Muenchh.)	1, 2, 3	22, 24, 37, 53, 54, 56	F-1, C-1
Water oak *Quercus nigra* (L.)	1, 2	42, 51, 52, 55	F-1, C-1
Pin oak *Quercus palustris* (Muenchh.)	1, 2	33, 36, 39, 41, 42, 53, 54, 55	F-1, C-1
Willow oak *Quercus phellos* (L.)	1, 2	55	F-1, C-1
Shumard oak *Quercus shumardii* (Buckl.)	1, 2	5, 24, 32, 36, 52, 55	F-1, C-1
Post oak *Quercus stellata* (Wang)	1, 2, 3	55	F-1, C-1
Live oak *Quercus virginiana* (Mill)	2, 3	5, 12, 14, 24, 32, 41, 51 52, 55	F-1, C-1
Black locust *Robinia pseudoacacia* (L.)	1, 2	35, 37, 54, 55, 56	F-3, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Black willow *Salix nigra* (Marsh) var. *nigra*	1, 2, 3	22	F-4, C-1
Western soapberry *Sapindus saponaria* (L.) var. *drummondii* (H.& A.) L. Benson	1, 2, 3	24, 52	F-3, C-2
Sassafras *Sassafras albidum* (Nutt.) Nees.	1, 2	24, 52, 56	F-1, C-1
American elm *Ulmus americana* (L.)	1, 2, 3	25	F-2, C-2
Cedar elm *Ulmus crassifolia* (Nutt.)	1, 2, 3	5, 12, 14, 24	F-2, C-1
Chinese date, jujube *Ziziphus jujuba* (Mill.)	1, 2, 3	22	F-1, C-1
Shrubs			
Serviceberry *Amelanchier* spp.	1, 2	54, 55	F-1, C-1
Indigobush *Amorpha fruticosa* (L.)	1, 2	22, 52, 56	F-1, C-1
Fourwing saltbush *Atriplex canescens* (Nutt.)	3	15, 20, 22, 47, 49, 56	F-2, C-1
American beautyberry *Callicarpa americana*	1, 2	24, 32	F-1, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Buttonbush *Cephalanthus occidentalis* (L.)	1, 2, 3	11, 37	F-1, C-1
Silky dogwood *Cornus amomum* (Mill.)	1, 2	35, 53, 54, 56, 57	F-1, C-1
Rough-leaf dogwood *Cornus drummondii*(C. A. May)	1, 2, 3	24	F-1, C-1
Flowering dogwood *Cornus florida* (L.)	1, 2	12, 14, 52, 53, 55, 56, 57	F-1, C-1
Hawthorn *Crataegus* spp.	1, 2	36, 52, 53, 55, 56	F-1, C-1
Russian olive *Elaeagnus angustifolia* (L.)	1, 2, 3	12, 23, 32, 34, 36, 37, 41, 42, 52, 53, 54, 55, 57	F-1, C-1
Autumn olive *Elaeagnus umbellata* (Thumb.)	1, 2	16, 32, 35, 37, 53, 54, 55, 56, 57	F-1, C-1
Euonymus *Euonymus bungeanus* (Maxim.)	1, 2	37, 54	F-1, C-1
Texas kidneywood *Eysenhardtia texana* (Scheele)	2, 3	11, 22, 56	F-2, C-2
Elbowbush *Forestiera pubescens* (Nutt.)	1, 2	24	F-2, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Possumhaw, deciduous holly *Ilex decidua* (Walt.)	1, 2	51, 52	F-1, C-1
American holly *Ilex opaca* (Ait.)	1, 2	12, 32, 52, 55, 56	F-1, C-1
Winterberry *Ilex verticillata* (L.) Gray	1	56	F-1, C-1
Yaupon *Ilex vomitoria* (Ait.)	1, 2, 3	12, 14, 16, 32, 41, 52	F-1, C-1
Pfitzer juniper *Juniperus chinensis* (L.)	2	12, 32, 33, 36, 41, 51, 54	F-3, C-1
Shrub lespedeza *Lespedeza bicolor* (Turcz.)	1, 2	13, 19, 20, 34, 35, 44, 45, 46, 49, 55, 57.	F-2, C-1
Amur privet *Ligustrum amurense* (Carr.)	1, 2	36, 42, 49, 57, 55	F-3, C-2
Bayberry, waxmyrtle *Myrica cerifera* (L.)	1, 2, 3	52	F-1, C-1
Wild plum *Prunus americana* (Marsh.)	1, 2, 3	22, 37, 47, 54, 56	F-1, C-1
Cherry laurel *Prunus caroliniana* (Mill.) Ait.	1, 2	12, 14, 32, 36, 41, 51, 52, 55	F-2, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Wild cherry, chokecherry *Prunus virginiana* (L.)	1, 2, 3	52, 53, 56	F-1, C-1
Pyracantha, firethorn *Pyracantha angustifolia* (Franch.)	1, 2, 3	14, 51	F-1, C-1
Carolina buckthorn *Rhamnus caroliniana* (Walt.)	1, 2, 3	24	F-1, C-1
Skunkbush, fragrant sumac *Rhus aromatica* (Ait.)	1, 2, 3	22, 35, 37, 53, 55	F-1, C-1
Flameleaf, shining sumac *Rhus copallina* (L.)	1, 2, 3	11, 35, 52, 55	F-1, C-1
Bristly locust *Robinia fertilis* (Ashe)	1, 2	35, 54	F-2, C-1
Multiflora rose *Rosa multiflora* (Thumb.)	1, 2	37, 53, 54, 55	F-1, C-1
Elderberry *Sambucus canadensis* (L.)	1, 2, 3	11, 55, 56, 57	F-1, C-1
Coral berry, snowberry *Symphoricarpos orbiculatus* (Moench)	1, 2	24, 35, 55	F-1, C-1
Arrow-wood *Viburnum dentatum* (L.)	1	53	F-1, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Vines			
Peppervine *Ampelopsis arborea* (L.) Koehne.	1, 2, 3	24	F-1, C-3
Trumpet creeper *Bignonia radicans* (L.)	1, 2, 3	55	F-2, C-1
American bittersweet *Celastrus scandens* (L.)	1, 2, 3	35, 53, 54, 55	F-1, C-1
Carolina jessamine *Gelsemium sempervirens* (L.)	1, 2	12, 14, 32	F-2, C-1
Japanese honeysuckle *Lonicera japonica* (Thumb.)	1, 2, 3	11, 12, 14, 32, 36, 41, 55	F-1, C-1
Tatarian honeysuckle *Lonicera tatarica* (L.)	1, 2, 3	36, 52, 53, 54, 55	F-1, C-1
Matrimony vine *Lycium halimifolium* (L.)	1, 2, 3	55	F-2, C-1
Virginia creeper *Parthenocissus quinquefolia* (L.) Planch.	1, 2, 3	52, 55, 56	F-1, C-1
Dewberry, blackberry *Rubus* spp.	1, 2, 3	28, 33, 36, 42, 57	F-1, C-1
Wild grape *Vitis* spp.	1, 2, 3	24, 57	F-1, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Leguminous Forbs			
Partridge pea, prairie senna *Cassia fasciculata* (Michx.)	1, 2	11, 22, 44, 45, 46, 57	F-1, C-3
Crownvetch *Coronilla varia* (L.)	1, 2	7, 13, 15, 20, 49, 53, 57	F-2, C-3
Bundleflower *Desmanthus illinoensis* (Michx.) Mac M.	2	22	F-2, C-2
Wild pea *Lathyrus hirsutus* (L.)	1, 2	13, 57	F-2, C-1
Sericea lespedeza *Lespedeza cuneata* (Dum Cours.,G.Don.)	1, 2	20, 29, 31, 34, 38, 44 46, 48, 49, 50, 57	F-2, C-2
Korean lespedeza *Lespedeza stipulacea* (Maxim)	1, 2	13, 20, 31, 34, 46, 48, 49 57	F-2, C-2
Common lespedeza *Lespedeza striata* (Thumb. ex J.Man)	1, 2	13, 20, 34, 48, 49, 57	F-2, C-2
Birdsfoot trefoil, deervetch *Lotus corniculatus* (L.)	2	15, 47, 57	F-2, C-2
Sweetclover *Melilotus* spp.	2, 3	13, 15, 20, 21,27, 31, 34, 38, 49	F-2, C-2
Purple prairieclover *Petalostemum purpureum* (Vent.) Rudb.	2	11, 20, 22, 49	F-3, C-2

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Sesbania *Sesbania exaltata* (Raf.) Cory.	1, 2, 3	35, 48, 57	F-2, C-3
Trailing wildbean *Strophostyles helvola* (L.) Ell.	1, 2, 3	22	F-1, C-2
Crimson clover *Trifolium incarnatum* (L.)	1, 2	4, 7, 13, 19, 20, 21, 27, 31, 34, 48, 49	F-2, C-2
White clover *Trifolium repens* (L.)	1, 2, 3	7, 13, 20, 21, 27, 31, 34, 44, 48, 49, 57	F-2, C-3
Arrowleaf clover *Trifolium vesiculosum*	1, 2	13, 20, 31, 49	F-2, C-2
Hairy vetch *Vicia villosa* (Roth.)	2	1, 7, 15, 19, 20, 31, 44, 48, 50	F-3, C-2
Non-Leguminous Forbs			
Engelmann daisy *Engelmannia pinnatifida* (Nutt.)	2, 3	11, 15, 22	F-2, C-3
Firewheel, Indian blanket *Gaillardia pulchella* (Foug.)	2, 3	11, 47	F-2, C-3
Common sunflower *Helianthus annuus* (L.)	1, 2, 3	11, 47	F-1, C-1
Maximilian sunflower *Helianthus maximiliani*	2, 3	11, 20, 22, 49	F-1, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Bush sunflower *Simsia calva* (Engelm. and Gray)	3	22	F-2, C-1
Goldeneye *Viguiera dentata* (Cav.)Spreng.	2	11, 15	F-2, C-3
Grasses			
Big bluestem *Andropogon gerardii* (Vitm.)	1, 2, 3	13, 15, 20, 21, 22, 27, 34, 38, 49, 56, 57	F-3, C-2
Little bluestem *Andropogon scoparius* (L.)	2, 3	6, 10, 13, 15, 20, 21, 22, 27, 34, 38, 49, 57	F-3, C-2
Sideoats grama *Bouteloua curtipendula* (Michx.)	2, 3	3, 6, 8, 10, 13, 15, 17, 20, 22, 31, 34, 38, 49	F-2, C-3
Blue grama *Bouteloua gracilis* (H.B.K.)	2	10, 13, 15, 17, 20, 22, 31, 34, 49	F-3, C-4
Rescuegrass, bromegrass *Bromus unioloides* (H.B.K.)	1, 2, 3	13, 15, 20, 31, 48	F-2, C-3
Buffalograss *Buchloe dactyloides* (Nutt.) Engelm.	1, 2, 3	3, 6, 10, 13, 15, 17, 20, 22, 31, 49	F-3, C-4
Buffelgrass *Cenchrus ciliaris* (L.)	3	6, 8, 17, 21, 22, 48	F-3, C-2
Bermuda grass *Cynodon dactylon* (L.) Pers.	1, 2, 3	4, 8, 13, 15, 17, 20, 21, 29, 30, 34, 48, 49	F-4, C-3

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Weeping lovegrass *Eragrostis curvula*(Shrad.)New.	1, 2, 3	4, 10, 13, 15, 20, 31, 38, 40, 46, 48, 49	F-3, C-2
Tall fescue *Festuca arundinacea*(Sreb.)'K-31'	1, 2	10, 13, 20, 31, 48, 49	F-3, C-2
Green sprangletop *Leptochloa dubia*(H.B.K.) Nees	2, 3	8, 10, 13, 15, 20, 49	F-3, C-3
Perennial ryegrass *Lolium perenne* (L.)	1, 2	10, 13, 20, 31, 47, 48, 49	F-3, C-3
Kleingrass *Panicum coloratum* (L.)	1, 2, 3	3, 4, 6, 7, 8, 10, 13, 15, 17, 20, 21, 22, 27, 49	F-2, C-3
Vine-mesquite *Panicum obtusum* (H.S.K.)	2, 3	15, 17	F-2, C-2
Switchgrass *Panicum virgatum* (L.)	1, 2, 3	1, 3, 4, 6, 7, 8, 9, 10, 13, 15, 17, 18, 20, 21, 22, 27, 34, 38, 49, 57	F-1, C-2
Dallisgrass *Paspalum dilatatum* (Poir)	1, 2	13, 48	F-2, C-3
Bahiagrass *Paspalum notatum* (Flugge)	1	4, 6, 7, 13, 19, 27, 31, 48	F-2, C-3
Plains bristlegrass *Setaria leucopila* (Scribn. and Merr.)	2, 3	8, 10, 20, 49	F-2, C-3

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Indiangrass *Sorghastrum nutans*(L.) Nash.	1, 2, 3	10, 13, 15, 20, 22, 49	F-2, C-2
Johnsongrass *Sorghum halepense* (L.) Pres.	1, 2, 3	8, 13, 15, 48	F-3, C-2
Sand dropseed *Sporobolus cryptandrus*(Torr.) Gray.	2, 3	15, 20	F-2, C-3
Eastern gamagrass *Tripsacum dactyloides* (L.)	1, 2	22	F-3, C-3
Marsh and Aquatic Plants			
Giant reed *Arundo donax* (L.)	2, 3	22	F-4, C-1
Nutgrass, chufa *Cyperus esculentus* (L.)	1, 2, 3	44, 48	F-2, C-3
Japanese millet *Echinochloa crusgalli*(L.) Beauv.	1, 2	35, 44, 46, 48, 57	F-1, C-2
Reed canarygrass *Phalaris arundinacea* (L.)	1, 2, 3	15, 20, 49, 57	F-3, C-2
Common reed *Phragmites communis* (Trin.)	1, 2, 3	22, 57	F-4, C-1
Smartweed *Polygonum pensylvanicum* (L.)	1, 2, 3	47, 57	F-1, C-1

Appendix C. (Continued)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Pondweed *Potamogeton* spp.	1, 2, 3	57	F-1, C-4
Bulrush *Scirpus* spp.	1, 2, 3	57	F-3, C-1
Prairie cordgrass *Spartina pectinata* (Link.)	1, 2, 3	6, 22	F-4, C-1
Cattail *Typha* spp.	1, 2, 3	57	F-4, C-1
Wild rice *Zizania aquatica* (L.)	2, 3	57	F-1, C-2
Cultivated Food and Cover Crops			
Oats *Avena sativa* (L.) Thell.	1, 2, 3	20, 48	F-1, C-2
Barley *Hordeum vulgare* (L.)	1, 2, 3	13, 48, 57	F-1, C-2
Alfalfa *Medicago sativa* (L.)	1, 2	1, 13, 15, 20, 31, 38, 40, 48, 49	F-2, C-2
Rice *Oryza sativa* (L.)	1	26, 48, 57	F-1, C-2
Millet *Panicum* spp.	1, 2	7, 13, 40, 44, 45, 46, 48, 57	F-1, C-2

Appendix C. (Concluded)

Species	Adaptability[a]	Seed or plant stock availability[b]	Wildlife value[c]
Winter rye *Secale cereale* (L.)	2	10, 13, 15, 20, 48	F-2, C-2
Sudangrass, forage sorghum *Sorghum sudanense* (Piper) Staph.	1, 2, 3	1, 8, 15, 20, 34, 40, 48, 50	F-3, C-2
Milo, grain sorghum *Sorghum vulgare* (Pres.)	1, 2, 3	1, 15, 20, 48, 50, 57	F-1, C-2
Wheat *Triticum* spp.	2	13, 48, 57	F-1, C-3
Cowpeas *Vigna unguiculata* (L.) Walp.	1, 2, 3	4, 7, 13, 15, 21, 31, 34, 35, 40, 46, 48	F-2, C-2
Corn *Zea mays* (L.)	1, 2, 3	13, 35, 57	F-1, C-2
Wildflowers and native plants	1, 2, 3	11, 47, 52, 55, 56	Variable

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[a] Vegetation region adaptability for Texas/Oklahoma after Duck and Fletcher (1943), Gould (1975), and Whiteley and Hossner (1980):

1 - Pineywoods (oak-pine; loblolly pine)
2 - Post Oak Savannah (post oak - blackjack; oak - hickory)
3 - South Texas Plains (mesquite, post oak, liveoak, many grasses)

[b] Refer to Appendix D for seed or plant stock sources for the listed vegetation species. Individual dealers should be consulted for plant materials availability.

[c] F = Food; C = Cover; 1 = Excellent; 2 = Good; 3 = Fair; 4 = Limited.

APPENDIX D. List of seed and/or planting stock sources for the Texas-Oklahoma area.[3]

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[3] Referenced dealers of planting stock and seed are listed by assigned code numbers which correspond to the "availability" column in Appendix C.

APPENDIX D

TEXAS

1. Asgrow Seed Company
P.O. Drawer A
San Antonio, TX 78211
512-922-6361

2. Austin Tree Farm, Inc.
1935 Berkeley
Austin, TX 78745
512-444-3117

3. Bamert Seed Company
Route 3, Box 192
Muleshoe, TX 79347
806-272-4787

4. Conlee Seed Company
P.O. Box 267
Waco, TX 76228
817-772-5680

5. Dallas Nurseries, Inc.
12501 Preston Road
Dallas, TX 75230
214-239-1331

6. Douglas W. King Company
Box 20320
San Antonio, TX 78286
512-661-4191

7. Empire Seed Company
109 East Avenue A
Temple, TX 76501
817-778-7109

8. Foster-Rambie Grass Seed
326 North 2nd Street
Uvalde, TX 78801
512-278-2711

9. Garrison Seed Company
Box 927
Hereford, TX 79045
806-364-0560

10. George Warner Seed Company, Inc.
P.O. Box 1448
Hereford, TX 79045
806-364-4470

11. Green Horizons
500 Thompson Drive
Kerrville, TX 78028
512-257-5141

12. Green Valley Nurseries, Inc.
P.O. Box 548
Floresville, TX 78114
512-393-3161

13. Harpool Seed Inc.
P.O. Drawer B
Denton, TX 76201
817-387-0541

14. Hawkins Nursery & Landscape
P.O. Box 208
Grand Saline, TX 75140
214-962-3622

15. Horizon Seed, Inc.
P.O. Box 886
Hereford, TX 79045
806-364-5250

16. McVicar Organic Nursery
2710 South Street
Nacogdoches, TX 75961
713-564-7691

17. Pogue Seed Company
P.O. Drawer 389
Kenedy, TX 78119
512-583-3456

18. Robinson Seed Company
1107 Yonkers
Plainview, TX 79072
806-293-4959

19. Rudy-Patrick Seed Company
Box 218
Garland, TX 75040

20. Sharp Brothers Seed Company
4378 Canyon Drive
Amarillo, TX 79109
806-352-2781

21. Star Seed & Grain Corp.
415 Blue Star Street
San Antonio, TX 78204
512-227-5344/800-292-5686

22. Soil Conservation Service
Plant Materials Center
Route 1, Box 155
Knox City, TX 79529
817-658-3922

23. Texas Forest Service
Indian Mound Nursery
P.O. Box 617
Alto, TX 75925
713-858-4202

24. Texas Native Plants Nursery
3105 Lafayette Street
Austin, TX 78722
512-473-8718

25. Texas Pecan Nursery, Inc.
Box 306
Chandler, TX 75758
214-849-6203

26. Texas-West Indies Company
P.O. Box 110
El Campo, TX 77437
713-543-2741

27. W. H. Anton Seed Company
P.O. Box 667
Lockhart, TX 78644
512-398-2433

28. Womack's Nursery Company
Route 1, Box 80
DeLeon, TX 76444
817-893-6497

OKLAHOMA

29. Cedarlake Sod Farm, Inc.
Route 2, Box 43K
Shawnee, OK 74801
405-273-4920

30. Coury Enterprises
2828 Northwest 5[illegible]
Oklahoma City, [illegible]112
405-848-4411

31. Eckroat Seed Company, Inc.
P.O. Box 17610
Oklahoma City, OK 73136
405-427-2484

32. Greenleaf Nursery Company
Route 1, Box 163
Park Hill, OK 74451
918-457-5172

APPENDIX D. (Continued)

33. Honey Creek Nursery
Route 4, Box 514
Grove, OK 74344
918-786-2771

34. Johnston Seed Company
Box 1392
Enid, OK 73701
405-233-5800

35. Melot's Inc.
P.O. Box 154
Bethany, OK 73008
405-721-4394

36. Mid-Western Nurseries, Inc.
P.O. Box 768
Tahlequah, OK 74464
918-456-6185/800-331-4145

37. OK Dept. of Agriculture
Forestry Division Nursery
Route 1, Box 44
Washington, OK 73093
405-288-2385

38. Ross Seed & Grain Company
P.O. Box 769
Chickasha, OK 73018
405-224-2224

39. Spears Tree Farm
Route 1, Box 138
Tahlequah, OK 74464
918-456-4293

40. The Great American Seed Co.
P.O. Box 725
Hennessey, OK 73742
405-853-7811

41. Twam Nurseries, Inc.
Route 1
Pauls Valley, OK 73075
405-283-5116

42. Valley View Nursery
Route 1, Box 400
Park Hill, OK 74451
918-456-3241

43. Weyerhaeuser Company
Route 1, Box 10A
Ft. Townson, OK 74735
405-873-2717

ADDITONAL SOURCES

44. Bomar Feed and Seed Company
P.O. Box 1327
Tuscaloosa, AL 35401
205-758-3671

45. Montgomery Seed and Supply
243 Dexter Avenue
Montgomery, AL 36104
205-265-8241

46. Kaufman Seeds, Inc.
P.O. Box 398
Ashdown, AR 71822
501-898-3328

47. Clyde Robin Seed Co., Inc.
P.O. Box 2855
Castro Valley, CA 94546
415-581-3467

APPENDIX D (Concluded)

48. Bingham Seed Company, Inc.
P.O. Box 1166
Jacksonville, FL 32201
904-768-1503

49. Sharp Brothers Seed Company
Healy, KA 67850
316-398-2231

50. Louisiana Seed Company, Inc.
P.O. Box 7498
Alexandria, LA 71306
318-445-6900

51. Richard's Nursery, Inc.
P.O. Box 130
Forest Hill, LA 71430
318-748-8587 (8484)

52. VBM Seeds
4607 Wendover Blvd.
Alexandria, LA 71301
318-443-7902

53. Forest Keeling Nursery
Elsberry, MO 63343
314-898-5571

54. Plumfield Nurseries, Inc.
P.O. Box 410
Fremont, NE 68025
402-721-3622

55. Hillis Nursery Company
Route 2, Box 142
McMinnville, TN 37110
615-688-4364

56. Native Plants
University Research Park
400 Wakara Way
Salt Lake City, UT 84108
801-486-8154

57. Kester's Wild Game Food
Nurseries, Inc.
P.O. Box V
Omro, WI 54963
414-685-2929

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This guide includes procedures and discussions encouraging the preservation and reclamation of surface mined lands in Texas and Oklahoma for wildlife. Even on those sites where reclamation will be oriented primarily toward agricultural purposes (e.g., tame pasture, commercial forest, etc.), there are numerous ways to include wildlife in the reclamation plan. Methods and procedures are recommended in this guide that will make possible the creation of a diversity in habitats that will make possible the creation of a diversity in habitats that will attract and support wildlife. The specific purpose of this publication is to provide guidance on the conception, development, and implementation of revegetation plans that help to retain, create, and maintain wildlife habitat on reclaimed lands in Texas and Oklahoma.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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